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UITGEGEVEN DOOR

Dr. MAX WEBER
Prof. in Amsterdam, Leider der Expeditie

(met medewerking van de Maatschappij ter bevordering van het Natuurkundig Onderzoek der Nederlandsche Kolonien)

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THE

CODIACEAE OF THE SIBOGA EXPEDITION

including a Monograph of FLABELLARIEAE and UDOTEAE

BY

A. & E. S. GEPP
London

With 22 plates

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GENERAL INTRODUCTION.

The basis upon which this paper is founded is the collection of Codiaceae, made by Madame WEBER VAN BOSSE during the Siboga Expedition to the East Indian Archipelago in 1899 and 1900, and kindly entrusted by her to us for examination. No less than nine genera of Codiaceae are represented in that region — namely, *Chlorodesmis*, *Avrainvillea*, *Rhipilia*, *Penicillus*, *Boodleopsis* (nov. gen.), *Tydemania*, *Udotea*, *Codium*, *Halimeda*. Some of the plants were difficult to determine, partly owing to the disappearance or inaccessibility of type specimens, and partly because some of the genera had been built up piecemeal and thrown into confusion by the addition of species which either did not really belong to the genus or were not easily distinguishable from species previously existing but insufficiently defined. Where this has been the case we have been compelled to make a complete study of the respective genera, and to include therein our determinations of the Siboga specimens.

Thus, inter alia, have we treated *Chlorodesmis*, *Avrainvillea*, *Rhipilia*, *Penicillus*, *Tydemania* and *Udotea*; while *Halimeda* has already been monographed in a separate paper in 1901 (Siboga-Expeditie Monogr. LX).

The Siboga collection of Codiaceae provided two new genera, *Tydemania* Web. v. Bosse (Ann. Jard. Bot. Buitenzorg 2e sér., vol. II, 1901, p. 139) and *Boodleopsis*, and nine new species and one variety: — *Rhipilia orientalis*, *Boodleopsis siphonacea*, *Tydemania expeditionis* Web. v.

Bosse loc. cit., *Penicillus Sibogae*, *Udotea papillosa*, *U. subpapillata*, *U. explanata*, *Codium divaricatum*, *C. petaloideum*, and *Udotea argentea* var. *spumosa*. The other novelties described here, apart from the Siboga material are — *Chlorodesmis Hildebrandtii*, *Avrainvillea clavatiramea*, *A. Ridleyi*, *A. canariensis*, *A. Elliottii*, *A. pacifica*, *A. lacerata* var. *robustior*, *A. amadelpha* f. *Montagneana* and f. *submersa*, *Rhipiliopsis* (nov. gen.) *peltata*, *Rhipilia tomentosa* f. *zonata*, *R. tenuiculmis*, *Rhipidodesmis* (nov. gen.) *caespitosa*, *Tydemania Gardineri*, *Udotea indica*, *U. spinulosa* var. *paluettoides*, *U. occidentalis*, *U. verticillosa* (full description), *U. Wilsoni*.

In studying such a genus as *Penicillus*, it became necessary to take into account *Rhipocephalus*, which was for a long time included in *Penicillus* and seemed almost to link on to that genus through the species *R. oblongus*. *Rhipocephalus* is a purely West Indian genus and has never been recorded from the Eastern hemisphere; nevertheless we consider its mention in the present paper to be indispensable as completing the comparative study and phylogeny of the flabelliferous members of the Udoteae, especially in relation to the Siboga-genus *Tydemania*.

We have been compelled to separate off from *Udotea* the Australian species *U. peltata* J. Ag., which in general structure really comes nearer to *Rhipilia* or *Avrainvillea* than to *Udotea*. From all these genera it is however distinguished by the possession of one remarkable peculiarity, which necessitates the creation of a new genus for its reception. To this we have given the name of *Rhipiliopsis*, and we have appended an account of this little known plant with figures of its peculiar internal structure.

Two other species which we have found reason to remove from *Udotea* on the ground of their evident affinity with *Chlorodesmis comosa*, are the ancient and well-known *U. Desfontainii* of the Mediterranean and the primitively developed and recently discovered *U. minima* of Ernst. To receive these two species we restore the genus *Flabellaria*, instituted by Lamouroux in 1813 for *F. Desfontainii*. *F. minima* is dimorphic and is particularly interesting as retaining in one of its forms indisputable traces of its evident derivation from a simple *Chlorodesmis*-like ancestor. As we show elsewhere (p. 48) these two green and uncalcified species are quite out of harmony with the true species of *Udotea*, which are calcified and form an exceedingly interesting and connected series of developmental stages easily traceable back to the simple little flabellate species *U. javensis* (*Rhipidosiphon* of Montagne). As now arranged, *Udotea* proper is a tropical genus, whereas *Flabellaria* is confined to the Mediterranean and to the islands off Northwest Africa.

Turning now to the question of relationship between the various genera composing the Family Codiaceae, we think that it is natural to separate them into three distinct groups, the Codieae, the Flabellarieae and the Udoteae. The Codieae consist of two genera — *Codium* and *Pseudocodium* — which are characterised by the possession of a cortical layer of utricles, loose or combined into a pseudo-parenchyma. *Codium* is a spongy feltwork which assumes various shapes characteristic of the various species, and its cortical layer consists of more or less enlarged assimilatory utricles, contiguous but not welded together into a continuous tissue. These utricles vary in shape and size according to the species. Growth is not confined to any particular region, as it is in *Pseudocodium*, where the principal growth is at the apices and is continuous.

Moreover in *Pseudocodium* the utricles firmly cohere together into a continuous pseudocortex, and arise directly from the medullary filaments. *Pseudocodium* was described and figured by Madame WEBER VAN BOSSE in the Journal of the Linnean Society Bot. vol. XXXII. 1896 p. 209. And *Codium* we have briefly treated in an Appendix, confining our attention to an enumeration of the species represented in the Siboga collections.

The Flabellarieae are all destitute of calcification and consist of the following genera — *Chlorodesmis*, *Avrainvillea*, *Rhipiliopsis*, *Flabellaria*, *Rhipilia*, *Cladocephalus*, *Rhipidodesmis*, *Callipsygma*, *Boodleopsis*.

The Udoteae are all calcified and are as follows: — *Tydemania*, *Penicillus*, *Rhipocephalus*, *Udotea*, *Halimeda*.

Our attention in the present paper has been directed chiefly to the genera of the Flabellarieae and Udoteae, which are much more nearly related to one another by external habit or by peculiarities of structure than either group is to the Codieae. Some of these peculiarities are as follows: —

1). Dichotomial branching repeated either in *one* and the same plane, or in *alternate* planes. Where the internodes (pseudo-articuli) are short and laterally contiguous *in one plane* they combine to form a flabellule. Such simple flabellules are found uncalcified in *Rhipidodesmis caespitosa* apparently (see p. 62) and in *Callipsygma*; they are calcified in *Udotea javensis*, *U. papillosa*, *U. glaucescens*, *Tydemania* and *Rhipocephalus*. Where the internodes (pseudo-articuli) are short and divergent, and the dichotomies lie more or less in *alternate* planes, they are either laxly interwoven into a cushion as in *Boodleopsis*, a laxly intricated glomerulus as in *Tydemania expeditionis*, or an intricated capitulum as in *Penicillus pyriformis*. The pseudo-articuli are longer, little interwoven, and form a brush in other species of *Penicillus*; they are subparallel in the uncalcified tuft of *Chlorodesmis comosa*, and also in the complanate frond of *Udotea conglutinata* and its allies where they are cemented together by a thin calcareous deposit.

2). Trichotomial branching occurs in addition to dichotomial, in the basal part of *Chlorodesmis comosa*, in *Boodleopsis*, in *Tydemania*, in *Penicillus Sibogae*, in the capitulum of *P. dumetosus* and in the flabellum of *Udotea conglutinata* and *U. glaucescens*.

3). Verticillate branching occurs in *Tydemania expeditionis*, in *Boodleopsis* and in the capitulum of both species of *Rhipocephalus*.

4). Lateral outgrowths of the main filaments. These are of two sorts: —

a). Papillae or short prominences. Papillae are numerous in *Udotea papillosa*. They are borne on the front and back surfaces of the filaments and not on their sides. They are not calcified at their apices, and probably serve either as osmotic channels between the cytoplasm and the seawater, or as windows in the opaque calcareous sheath. In *U. indica* large truncate or peltate papillaeform prominences cover the two surfaces of the very sparingly calcified frond, that is to say, they are borne upon the *exposed surface only* of the external filaments, and, fitting close together, form a primitive cortex of the frond.

b). True lateral outgrowths or stalked appendages. In *U. palmetta* the frond is more calcified than in *U. indica* and is covered with appendages similarly situated as in that species, but often bifurcate or even trifurcate and always pointed. The function of these

is not so evident. Similar but longer acute appendages occur also in *U. verticillosa*, and are often arranged in close whorls. Capitate appendages are borne upon the main filaments of the frond of *Udotea argentea* in very great numbers, and less numerously in *U. flabellum* and *Flabellaria petiolata*. In each species these terminal swellings or ramifications cohere together to form a continuous cortex covering the two surfaces of the frond, being much calcified in *U. argentea* and *U. flabellum*, and uncalcified in *Flabellaria petiolata*. A somewhat similar cortex is produced by the coherence and calcification of the apical ends of the lateral outgrowths which arise from the main filaments in the stipites of *Penicillus*, *Rhipocephalus* and all the species of *Udotea*, excepting the monosiphonous species *U. javensis* and *U. papillosa*.

c). Pseudo-lateral branches play a similar part in the formation of the labyrinthine cortex of the uncalcified genus *Cladocephalus*. Such branches are of dichotomous origin, but, remaining short, assume a lateral position and, undergoing much repeated dichotomous division, produce the characteristic intricated cortex. Pseudo-lateral branches also occur in *Rhipilia*, but have a different function. They do not form a cortex, but bear each a terminal digitate tenaculum or crown, employed either for linking on to an adjacent filament, or perhaps for thrusting it away (see p. 54).

d). Pseudo-conjugating filaments occur in *Rhipiliopsis*, consisting of short prominences arising laterally, one from each of two neighbouring filaments, and meeting end-on, never coalescing however but always remaining divided by a septum.

5. Habit. The habit is often characteristic of the genus. Among the different forms assumed are the following: — flabellate (*Udotea*); flabelliform (*Avrainvillea*, *Flabellaria*, *Udotea*, etc.); cyathiform (*Udotea cyathiformis*, *Rhipiliopsis*, *Rhipilia tenaculosa*, *R. orientalis*, *Cladocephalus excentricus*); capituliferous (*Penicillus*, *Rhipocephalus*); scopulaeform (*Cladocephalus scoparius*); glomeruliferous (*Tydemania expeditionis*); catenulate (*Halimeda*); caespitose (*Chlorodesmis*).

Comparative modes of growth in different genera. Growth in length is limited in some genera, continuous in others, and interrupted in others again. In *Penicillus* the growth in length of the stipes is terminated by the formation of the coma. In *Rhipocephalus* the growth in length is not terminated by the formation of a coma; but both stipes (rachis) and coma are continuously, though slowly, added to at the apex. In *Tydemania* the growth of the simple main axis is periodically interrupted during the formation of the glomeruli. In *Halimeda* the central strand of filaments ceases growth for a while after the formation of each segment. In *Udotea* the growth of the stipes is terminated by the formation of the flabellum; the flabellum of some species shows signs of interrupted growth at the zones (see p. 104) and at the proliferations.

Though supra-dichotomial constrictions are characteristic of the Udoteae as a whole, they do not occur in all the genera; for instance in *Rhipilia* and *Cladocephalus* they are usually absent, as also in *Udotea flabellum* and *U. verticillosa*. When present they are either (1) situated at the very base of the two branches emerging from the dichotomy (see fig. 3 *a*), as in the majority of genera: — *Chlorodesmis Hildebrandtii*, *Avrainvillea*, *Rhipilia*, *Flabellaria minima* (according to Ernst), *Rhipidodesmis*, *Callipsygma*, *Boodleopsis*,

Tydemania, *Penicillus*, *Rhipocephalus*, and half of the genus *Udotea* (West Indian species with one exception).

Or (2) they occur a little way above the base of the branches and at unequal levels (see fig. 47), as in *Chlorodesmis comosa*, *Udotea javensis*, *U. papillosa*, *U. glaucescens*, *U. orientalis*, *U. indica*, *U. palmetta*, *U. argentea* and *Flabellaria petiolata*.

The characteristic annular ingrowths and "stoppers" of Codiaceae have been so studied and described as to require no special attention here. They occur in *Codium*, *Chlorodesmis*, *Rhipilia*, *Rhipidodesmis*, *Callipsygma*, *Espera* (i.e. *Penicillus*), and possibly in other genera.

Calcification. All of the genera of the Udoteae are calcified. What is known of the nature of the calcareous deposit has been summarised by Oltmanns (Morphologie und Biologie der Algen II. 1905, p. 80). The researches of Meigen and others on calcareous algae in general show that the calcium carbonate of the deposit may be in the form of aragonite or of calcite, which two compounds can easily be distinguished from one another by means of cobalt nitrate. The aragonite or calcite is never quite pure, but is mixed with magnesium carbonate or with calcium oxalate in varying quantities, in different climates and in the different genera. There is need of further investigation in this direction. The calcareous matter is deposited in the gelatinous layers of the outer wall, penetrating also into the cellulose inner wall. Though the degree of calcification is to some extent a specific property, it also appears to depend upon the degree of insolation to which a given plant is exposed; for it may at least be expected that it would be proportional to the amount of photosynthesis effected.

As shown under *Udotea* (p. 102) and *Penicillus* (p. 72) there are two modes of calcification. In the first, the filaments of the frond or capitulum are enclosed each in a porose calcareous sheath (as shown in fig. 182). These filaments are either quite free as in the capitulum of *Penicillus*, and the glomeruli of *Tydemania expeditionis*; or they are laterally cemented side by side into monostromatic flabella as in *Udotea javensis*, *U. glaucescens*, *Tydemania*, *Rhipocephalus*; or they are more or less completely conglutinated together into a thicker (pluriseriate) flabelliform or cyathiform frond as in *U. conglutinata*, *U. cyathiformis*, etc.

The second mode of calcification is found in the cortex of the stipes of *Udotea*, *Penicillus*, *Rhipocephalus*, and in the frond of the corticated species of *Udotea*. The apices of the simple or branched lateral appendages of the main filaments of the stipes or frond are in this case arranged so as to form a cortical covering to the stipes or frond, and are laterally coherent into a continuous layer; the laterally cohering walls are thickened by a calcareous deposit; and the actual apices are left *free* of calcification, and thus function as "windows" (see p. 103), as in the cortical layer of the stipes of *Penicillus* (figs. 163, 168, 175) and *Rhipocephalus* (figs. 186, 192), of the stipes and frond of *Udotea flabellum* and *U. argentea*, and of the jointed thallus of *Halimeda*. How deeply this calcification penetrates into the thallus, and whether it is limited to the cortical region, or more or less fills the inner cavities, we do not know. But we should infer that it varies with the species and reaches for instance a deeper level in the rigid stipes of *Penicillus capitatus* than in the softer stipes of *P. Lamourouxii* var. *gracilis*.

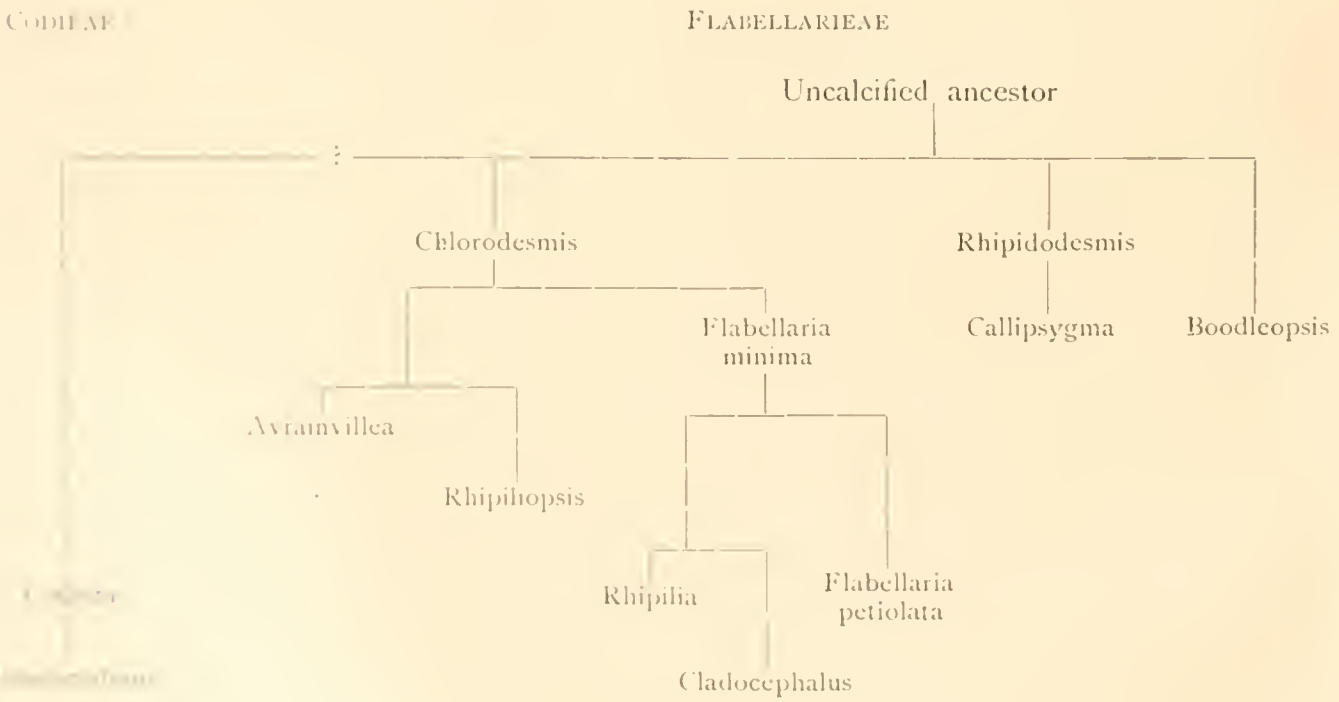
Pores and "windows". The pores, which are so abundant in the calcareous sheath

fig. 182) mentioned above as occurring in the first mode of calcification, are, as stated under *Udotea* (p. 72), minute spherical bubble-like chambers in the thickness of the calcareous layer. They are each covered externally by a delicate calcified pellicle, in which is a minute ostiole. This can be seen, but only in a *dry* specimen, with a microscope giving a magnification of 40 diameters.

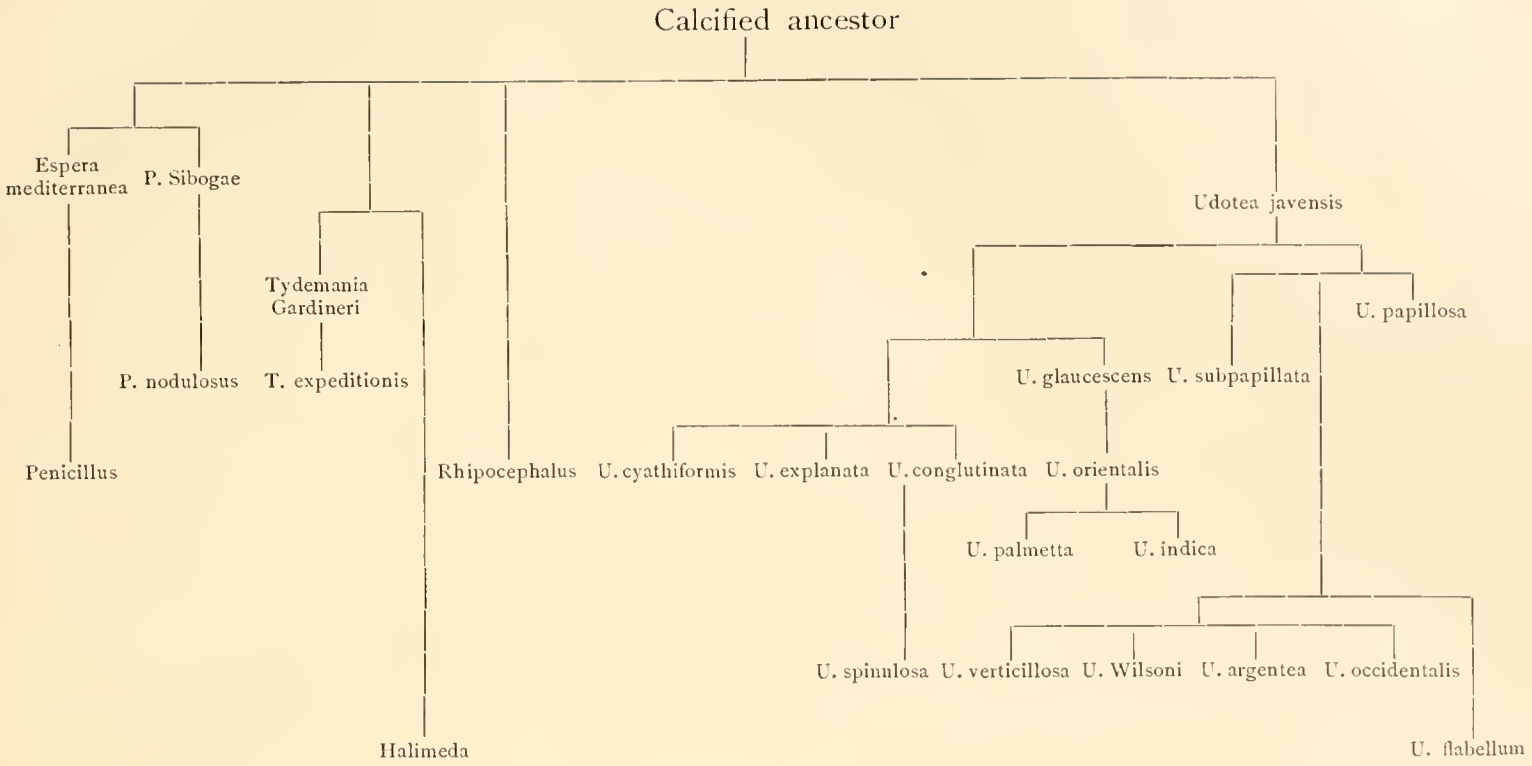
As suggested under *Udotea* (p. 102), the distribution of these pores (see fig. 182) probably corresponds with that assumed by the green chromatophores inside the filaments. The pores probably mark the spots where bubbles of oxygen were evolved during the photosynthetic process of the plant. And inasmuch as the deposition of the calcareous salts would be effected at the time of photosynthesis only, this deposition would necessarily be prevented at the numerous points at which the oxygen-bubbles are evolved and cling to the sides of the filament.

In the same way the uncalcified apices of the lateral appendages, described above in the second group as having the function of "windows", escape calcification owing to the presence of clinging bubbles of oxygen.

Affinities. The genera as defined in this paper either are calcified or are uncalcified: that is, the species in a given genus are either all of them calcified, or are all of them uncalcified. We believe that the two groups are fundamentally and physiologically distinct, and that their separation occurred far back in their developmental history. Another fundamental difference to which we attach great importance is found in the mode of branching, namely, whether the successive dichotomies are all in one and the same plane or in alternating planes. Imbued with these ideas we have drawn up the following genealogical tables as a concise expression of the conclusions to which we have been led.



UDOTEAE



In constructing these tables we have endeavoured to allocate the genera and sundry species according to their respective degrees of development along their various lines of descent. But it must not be supposed that we regard the simpler members as being the actual ancestors of the more highly differentiated. They do but indicate some of the stages in the developmental history of the group.

It will be found that there is very little parallelism between the two groups — calcified and uncalcified, such similarity as does occur being rather of the nature of coincidence. Nor is there much close affinity between them. It might be argued that *Flabellaria petiolata*, which under the name of *Udotea Desfontainii* has for nearly seventy years been regarded as an essential member of the genus *Udotea*, is of close affinity with *U. argentea* and *U. flabellum*. And, apart from the calcification, the similarity of frond-structure is, we admit, very great. But the ancestry of *Flabellaria petiolata* is unmistakeably revealed by the life history of *F. minima* (as described and figured by ERNST), which in its simplest stages could hardly be distinguished from a *Chlorodesmis*. The uncalcified genus *Flabellaria* has therefore a totally different origin from that of the calcified true species of *Udotea*, which as the table shows are easily traced back to a simple little calcified flabellate ancestor like *U. javensis*.

Chlorodesmis and *Rhipidodesmis* (*Chlorodesmis caespitosa* J. Agardh) are the most primitive extant forms of the Flabellarieae. *Chlorodesmis* certainly indicates the ancestry of *Flabellaria*, and probably that of the flabelliform genera, *Avrainvillea*, *Rhipiliopsis*, *Rhipilia*, and *Cladocephalus*; possibly also that of the Codieae (*Codium* and *Pseudocodium*). We are in doubt as to the position of *Boodleopsis*, whose peculiar habit is unique in the group.

As regards the position of *Cladocephalus* we are inclined to place it near *Rhipilia* (see p. 54) which in turn is probably allied with *Flabellaria minima*. *Rhipilia* and *Cladocephalus* are both uncalcified, are alike in possessing flabelliform and excentrically infundibuliform and zonate species, and also in being characterised by filaments dichotomously divided without constrictions and bearing pseudo-lateral branches, but in *Rhipilia* the pseudo-lateral branch terminates in a 2—6 fid tenaculum or crown, whereas in *Cladocephalus* it divides repeatedly and dichotomously at its apex to form the dense labyrinthine cortex.

Rhipidodesmis appears to be closely allied to *Callipsygma* and suggests its ancestry.

Passing to the calcified group, the Udoteae, we find that the most primitive forms known are *Ivyera mediterranea* and *Penicillus Sibogae* which indicate the ancestry of *Penicillus*, whose dichotomies lie in alternating planes. Another simple but slightly less primitive form is *Udotea javensis*, to which may be traced all the other species of *Udotea*, as shown in the table. *Udotea* is an exceptionally interesting genus in view of the series of developmental stages represented by its various species.

Rhipocephalus phoenix might be thought to spring from *Udotea javensis*; but the connection of *R. oblongus* with that species is less convincing. *Tydemania* and *Halimeda* are characterised by their periodically interrupted growth and show a striking parallelism of habit, combined with differences of detail. *Tydemania* consists of a chain of contiguous open uncorticated glomeruli strung together, so to speak, on a monosiphonous main axis (see p. 64); while in *Halimeda* the chain consists of contiguous closed corticated flabelliform articuli (or internodes) strung together on a polysiphonous axis.

For the further elucidation and revision of the true affinities between the genera of Codiaceae, it is much to be desired that a study be made of the youngest stages of growth (e.g. in *Rhipocephalus*), as well as experiments in regeneration (see p. 73); also that fresh genera and species may be discovered to aid in linking up the genera already known. The Siboga material has supplied two new genera — *Tydemania* and *Boodleopsis* — the former of which is remarkable for its dimorphic habit and interrupted growth.

Distribution. The Codiaceae flourish especially in tropical seas. Some of the genera are confined to the tropics, namely, *Chlorodesmis*, *Rhipilia*, *Cladocephalus*, *Rhipidodesmis*, *Boodleopsis*, *Tydemania*, *Rhipocephalus*. Some occur in the tropical and extra-tropical zones, namely, *Codium*, *Avrainvillea*, *Penicillus*, *Udotea*, *Halimeda*. The rest are found only outside the tropics, namely, *Pseudocodium*, *Rhipiliopsis*, *Flabellaria*, *Callipsygma*.

Comparing now East with West, we find the five large genera, *Codium*, *Avrainvillea*, *Penicillus*, *Udotea*, *Halimeda*, widely distributed in both hemispheres, where also *Rhipilia* and *Cladocephalus* occur more locally. Seven genera are known from the Eastern hemisphere only, namely, *Pseudocodium*, *Chlorodesmis*, *Rhipiliopsis*, *Rhipidodesmis*, *Callipsygma*, *Boodleopsis*, *Tydemania*. *Rhipocephalus* is confined to the West Indian region, and *Flabellaria* to the Mediterranean Sea.

Of all the species monographed in the present paper only one, *Udotea flabellum*, is found in both hemispheres, East and West, being indeed widely distributed throughout the tropical seas. A few species of *Halimeda* and *Codium* have a like distribution East and West.

Much of this work has of necessity been done in the Botanical Department of the British Museum, and the results are published with the permission of the Trustees. Representative portions of the material studied, photographs of borrowed types, and hundreds of camera-lucida and other drawings are placed for reference in the British Museum Herbarium.

Thanks to the kindness of Madame Dr. Weber van Bosse, Mons. Bornet, Prof. Lignier, Mons. Lortet, Mons. Hariot, Prof. Nordstedt and Major Reinbold we have been enabled to study the types of many of the species and to draw up fuller descriptions of them than have hitherto been published; while by other botanists — Dr. F. Börgesen, Mr. F. S. Collins, Dr. M. A. Howe and Prof. R. J. Harvey Gibson — we have been kindly permitted to examine collections, the comparison and study of which have enabled us to gain a wider knowledge of the variations exhibited by the respective species and a clearer conception of the mutual affinities of the genera.

Finally we would record our grateful appreciation of Professor and Madame Weber's kindness in inviting us to work out this interesting group of algae, and also in allowing us all the time which, owing to prolonged interruptions, became necessary for the completion of the work. To the officials of the Royal Gardens, Kew, we are greatly indebted for the readiness with which they have placed facilities for work at our disposal; and to Mr. W. R. Wilson of the Department of Printed Books at the British Museum for valuable help given in verifying references in sundry rare volumes unobtainable elsewhere.

SYNOPSIS OF GENERA.

I. Flabellarieae.

1. Chlorodesmis. (p. 13).

Plant uncalcified, green, tufted, composed of free filaments distantly dichotomously branched: filaments arising from a densely felted base, with upper dichotomies distant, upper constrictions either all asymmetric above each dichotomy, or all symmetric.

2. Avrainvillea. (p. 16).

Plant uncalcified, flabelliform (except in *A. Rawsoni*), stipitate (rarely subsessile): stipes more or less thick. Rhizome either well developed or scarcely developed. Frond varying in colour and outline, thick or thin, normally entire (digitate in *A. Ridleyi*), rarely zonate, composed of a more or less intimately interwoven felt-work of dichotomously branched filaments cylindric to moniliform, but without fibulae or lateral appendages; constrictions present, sometimes strongly marked at dichotomies. Sporangia terminal on filaments exserted from the flabellum.

3. Rhipiliopsis. (p. 45).

Plant uncalcified, green, excentrically subinfundibuliform to flabellate, stipitate; stipes thin, short. Frond thin, rarely zonate, composed of a lax felt-work of dichotomously branched filaments, cylindric, here and there attached by a pseudo-conjugation of two short prominences, which issue from neighbouring filaments.

4. Flabellaria. (p. 46).

Plant uncalcified, green, flabellate, stipitate; or forming caespitose tufts of free filaments (in the *Chlorodesmis*-like state of *F. minima*. Stipes slender, corticated (except in *F. minima*). Frond thin, either (in *F. petiolata*) corticated, composed of filaments monostromatically arranged, more or less contiguous, radiating from stipes to margin, and emitting lateral branchlets, the fibulate or botryoidally decompound heads of which, interlocked, form a close cortex over the frond; or (in *F. minima*) composed of filaments entirely free or slightly held together by a few simple lateral branchlets.

5. Rhipilia. (p. 53).

Plant uncalcified, green, cuneato-flabellate to excentrically subinfundibuliform, stipitate. Stipes thin. Frond thick or very thin, sometimes zonate, varying in outline, composed of a lax felt-work of dichotomously branched filaments, often not cylindric, bearing rather short pseudo-lateral branchlets terminated by a 2—6-fid tenaculum or crown, applied or free.

6. Cladocephalus. (p. 57).

Plant uncalcified. green or brown, of varied habit, scopulaeform, flabellate or excentrically subinfundibuliform, stipitate. Stipes thin. Frond or scopula composed of subparallel medullary filaments radiating from the stipes to the periphery, dividing dichotomously without constrictions. Pseudo-lateral branches thinner, tapering, densely and dichotomously subdivided at apex and forming a labyrinthine cortex.

7. Rhipidodesmis. (p. 62).

Plant uncalcified, green, filamentous, gregarious, laxly caespitose; filaments decumbent below, ascending above and complanato-fastigiate at apex; constrictions symmetric above each dichotomy. Upper dichotomies approximated.

8. Callipsygma. (p. 63).

Plant uncalcified, green, complanate. Stem flat, sparingly branched, plumosely fringed all along its edge with numerous subparallel patent green filaments. Filaments dichotomously divided above into narrow monostromatic flabellules. Supra-dichotomial constrictions even.

9. Boodleopsis. (p. 64).

Plant uncalcified, minute, forming small green felted cushions, consisting of an inconspicuous monosiphonous tapering axis, bearing branches repeatedly divided di- and trichotomously and divaricately at short intervals, and laxly intricated. Constrictions even.

II. Udoteae.

10. Tydemania. (p. 65).

Plant thinly calcified, dimorphic, consisting of a conspicuously cylindrical monosiphonous axis, either creeping and bearing numerous terminal flabella, or ascending and bearing verticils of ramifying branches which become interwoven into glomeruli. Constrictions even.

11. Penicillus. (p. 68).

Plant calcified, consisting of stipes and capitulum. Stipes compound, encrusted, not reaching apex of capitulum, consisting of a dense brush-like tuft of ascending free filaments dichotomously divided but not in one plane, evenly constricted above each dichotomy.

12. Rhipocephalus. (p. 91).

Plant calcified consisting of stipes and capitulum. Stipes compound, encrusted, percurrent to apex. Capitulum composed of flabellules, which are either *a*) normally small, imbricate, ascending, sometimes united together laterally into a series of verticillate overlapping collars, filaments of flabellules dichotomously divided in one plane and laterally coherent; or *b*) much less evidently flabellate, capitulum almost penicilloid in habit but having an apical cup-shaped depression in which is seen a verticil of the four youngest flabellules, filaments of flabellules dichotomously divided in one plate, not coherent, but contiguous. Supra-dichotomial constrictions even.

13. Udotea. (p. 99).

Plant calcified, generally flabellate, rarely excentrically subinfundibuliform, stipitate. Stipes slender, either monosiphonous, or compound and corticated. Frond monostromatic, distromatic or pluriseriate, uncorticated or corticated, composed of filaments radiating from stipes to margin *a*) either contiguously subparallel, thinly calcified, and not emitting lateral appendages or *b*) emitting acute or obtuse or truncate papillae, or *c*) medullary filaments separated from one another and emitting more or less abundant simple or divided lateral (or pseudo-lateral) branchlets or protuberances, which are acute, capitate or digitately decompound, and serve either to hold the filaments together or to form a cortex, thickly calcified. Constrictions even or uneven.

14. Halimeda. (See reference on p. 1).

Plant thickly calcified, composed of simple or branched subcomplanate chains of flattened, cylindrical articuli of various shapes and sizes. Each articulus composed of a medullary plexus of branched filaments, and a pseudo-parenchymatous cortical layer formed of laterally coherent pyriform or clavate utricles (branch-endings) more or less inflated and truncate above. In surface view pseudocortex more or less hexagonally areolate. Sporangia in racemes on dichotomous filaments exserted on edge or face of articuli. Constrictions long-necked, even (where present).

III. Codieae.

15. Codium. (p. 134).

Plant uncalcified, green, spongy, varied in form, pulvinate, globose, elongate, cylindrical, flattened, etc., simple or branched, composed of a loose felt-work of medullary filaments, and a cortical layer of contiguous, but not adherent, shortly clavate green inflated utricles (branch-endings).

16. Pseudocodium. (See reference on p. 3).

Plant uncalcified, green, cylindrical, branched, composed of a loose felt-work of longitudinally arranged branched medullary filaments, and a pseudo-parenchymatous cortical layer formed of laterally coherent oblong green inflated utricles (branch-endings) truncate above. Pseudocortex in surface view hexagonally areolate.

1. Chlorodesmis Bailey and Harvey
(Figs. 69—75).

Harvey Nereis Boreali-Americana Part III. in Smithsonian Contributions to Knowledge, X. (1858) p. 29; Bail. & Harv. in Wilkes U. S. Explor. Exped. XVII. Bot. 1862, p. 172, Algae tab. VIII, figs. 8—10; J. G. Agardh Till Alg. Syst. V. 1887. p. 48 (pro parte); De Toni Syll. Alg. I. 1889 pp. 439, 513; Engler und Prantl Die natürlichen Pflanzenfamilien I. 2. 1890. p. 141.

Mature plant usually felted at base so as often to form a colourless spurious stipes, and bearing above a radiating penicilloid tuft of free, green, uncalcified, straight, filaments; filaments in their lower part more or less constricted at irregular intervals, branched at short intervals, radicelliferous and colourless; in their upper part cylindrical, green, flaccid, dichotomously branched at longer intervals, constricted at the base of the branches.

This genus was founded upon *C. comosa*, which was first collected in the Fiji Islands by the United States Exploring Expedition of 1838—42 under Captain Wilkes. It was recognised by Bailey and Harvey as a distinct genus, and the official diagnosis was published in their report (loc. cit. 1862 p. 172). But before this official report appeared, Harvey described the genus in his Nereis Bor.-Amer. in 1858 (loc. cit.) in order to include a doubtful species from the West Indies, *C. vaucheriaeformis*, which has since been transferred to *Derbesia* by Prof. Farlow. Harvey had in the meantime himself visited the Friendly Islands, and there collected *C. comosa* abundantly on all the coral reefs, where he says, it forms a very striking object on the extreme outer edge of the reef.

In 1874, Zanardini described *C. major* collected by Fuliágar and Lind in Lord Howe Island, and pointed out that it has filaments twice as thick as those of *C. comosa*. We have never seen Zanardini's species.

In 1880, Kjellman published a description of his *C. pachypus* in Bot. Notiser, 1880, p. 117; he had himself collected the specimens of it at Labuan in Borneo, and issued samples under n° 343 in Wittrock and Nordstedt's Algae Exsiccatae. Kjellman's species was transferred to *Avrainvillea papuana* by Murray and Boodle in Journal of Botany XXVII, 1889, p. 71. *A. papuana* is synonymous with our *A. erecta* (p. 29; see also p. 31).

J. G. Agardh (loc. cit. p. 49) added another species, *C. caespitosa* (Ceylon, Ferguson n° 110), which in our opinion constitutes a separate genus, namely, *Rhipidodesmis* (see p. 62).

In 1889, Murray and Boodle (loc. cit. pp. 71, 72) transferred *C. comosa* and *C. caespitosa* to *Avrainvillea* contending that the former species "seems to stand in much the same relation to *Avrainvillea* as the *Espera* form does to *Penicillus*". They argue (loc. cit. p. 68) that *C. comosa* "is merely an *Avrainvillea* with the filaments free, instead of interwoven, and the rhizoid mass probably broken off short": and they call attention to "other forms exactly resembling *Chlorodesmis* (Ferguson's n° 290) which "are young growth forms connected by an unbroken series with mature forms of *Avrainvillea* — in this case *A. papuana*". We have examined Ferguson's series of specimens (Ceylon n° 290) illustrating the stages of growth of *A. papuana*, and we are unable to find sufficient likeness between its young forms and the

genus *Chlorodesmis* to justify in any way the transference of *C. comosa* to *Avrainvillea*. What is required is a proof that *C. comosa* ever quits its very characteristic tufted form and assumes a more highly organised habit, be it of *Avrainvillea* or of any other Siphoneous genus. This proof is entirely wanting, no variation from the normal growth having ever been recorded for the species in question.

1. *Chlorodesmis comosa* Bailey & Harvey

in Harvey Nereis Bor.-Amer. III. 1858. p. 29; & in Wilkes U. S. Explor. Exped. XVII 1862 p. 172. Algae, tab. VIII, figs. 8—10.
Chlorodesmis comosa Grunow in Reise Oesterr. Freg. Novara Bot. I. 1870 p. 35.
Chlorodesmis comosa Sonder Alg. Trop. Australiens in Hamburg Abhand. V. 2. 1871. pp. 67, 74. tab. VI, figs. 5—9; and in F. von Muller's Fragm. Phytogr. Austral. XI. Suppl. 1880. p. 38.
Avrainvillea comosa Murr. & Boodle Journ. of Bot. vol. XXVII. 1889 p. 71, tab. 289, fig. 12.
Avrainvillea comosa De Toni Syll. Alg. I. 1889 p. 515.
Chlorodesmis comosa Askenasy in Forsch. "Gazelle" Theil IV. Bot. 1889. Algen, p. 9.
Chlorodesmis comosa Okamura Illustr. Mar. Algae Japan vol. I. 1900 p. 13 pl. V.
Avrainvillea comosa Heydrich in Ber. deutsch. bot. Gesellsch. XXV. 1907 p. 101.
Chlorodesmis comosa A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908 p. 180; (Zool.) XII. 1909. p. 390.

Hab. PACIFIC. Fiji, U. S. Explor. Exped. — Ovalau, "*Challenger*" Expedition! — Friendly Islands: Vavau & Lifuka, 1855, *Harvey*, n° 90! — New Caledonia, *ex herb. Le Jolis*! — Solomon Islands, *Herb. Merrifield*! — New Hebrides, in *Herb. F. S. Collins*! — New Guinea, 1888, *Karnbach*! — Queensland, Port Denison, *Sonder*. — Upolu and Tongatabu, in *Herb. Mus. Brit.*! — Riukiu Islands, *Okamura*.

INDIC. Celebes: coral islands near Makassar, 1888, *Madame Weber van Bosse*! — Seychelles: Mahe, "*Valdivia*" *Expedition*. — Seychelles: Praslin, *J. Stanley Gardiner*!
Siboga Expedition. Stat. 312. Saleh Bay, Sumbawa, reef! — Stat. 86. Dongala, Celebes.

Plant up to 7 cm. high, with or without a stipes-like base, constituted of a pale spongy felt-work of basal branches and rhizoids, bearing a coma of free and radiating filaments above; basal filaments creeping, irregularly swollen and constricted, much and irregularly branched, emitting laterally branched stolons and rhizoids, and by dichotomy producing the ascending filaments; above the base the filaments are bright-green, torulose below, then cylindrical, straight, flaccid, 2—7 cm. long, 60—140 μ in diameter, distantly dichotomously branched, the resulting pair of branchlets being constricted once a little above the dichotomy, but at unequal distances. [Figs. 69—73].

HARVEY described this species as having a distinct and often elongate spongy stipes, but J. G. AGARDH, who discusses the character of the filaments in some detail, calls in question the propriety of regarding the spongy nidus as a stipes. The so-called stipes consists of a multiplication of rhizoids and basal branches intricately felted together, as carefully described by ASKENASY (loc. cit.) (compare figs. 69, 73 *a*).

The principal characteristics of typical specimens of *C. comosa* are the very obvious incrustations of the supra-dichotomial constrictions of the upper filaments (fig. 69 *b*, 72, 73 *b*), and the eight to ten, or even up to twenty, torulose constrictions which usually occur at the base of these filaments above their point of origin from the creeping basal portion (fig. 73 *c*). These constrictions are sometimes faintly discernible up to above the the third dichotomy. It

should be noted that the lowest pair of supra-dichotomial constrictions is usually even (Figs. 71, 73 *c*), that is, they are not situated at markedly unequal distances above the dichotomy.

Sonder and J. G. Agardh (loc. cit.) describe what they believe to be the sporangia of *Chlorodesmis*, situated in the apices of the free filaments. Madame Weber van Bosse noticed in her Dongala material, when freshly gathered, the escape of roundish, apparently non-motile, spores from the apex of one of the filaments.

We have seen no specimen of *Vaucheria fastigiata* C. A. Agardh (Syst. Algar. 1824 p. 176) which was collected by Gaudichaud at the Marianne Islands and referred by J. G. Agardh (Till Alg. Syst. V. 1887, p. 51) to *Chlorodesmis comosa* with some slight reservation. Should J. G. Agardh's opinion be be confirmed, the specific name *comosa* will have to give way and the present species must be called *Chlorodesmis fastigiata*. J. G. Agardh states that Gaudichaud's specimen is not in the best condition, as might well be expected if the plant really be identical with *C. comosa*.

Chlorodesmis comosa Mazé et Schramm (Algues de la Guadeloupe, Edit. II. 1870—79, p. 98) was collected at Guadeloupe ("Point à pitre, Ilet à Fajou; fragments de madrepores à la lame; 5 Avril 1868"), and was issued in Mazé's exsiccatae as n°. 338. It occurs, says Mazé (loc. cit.) "à petite distance du rivage, ... eaux troubles très-remuées..... Coloration: vert brunâtre dans l'eau".

The tufts are 20 cm. long; the filaments are pale green or hyaline, 80—150 μ thick, very remotely dichotomously branched, without constrictions at the dichotomies, thin-walled and collapsed. The plant has been referred by Murray and Boodle (loc. cit.) to *Vaucheria*, but is in our opinion an undescribed species of *Derbesia*. Some of the filaments in Mazé's specimens bear numerous lateral sessile sporangia, solitary and spaced out at intervals of 400—700 μ. These sporangia are apparently globose and have a diameter of 120 μ, which is also the diameter of the filament which bears them. But the filaments and sporangia are so irretrievably crushed in these dry old specimens as to render further investigation impossible to us.

Avrainvillea comosa Börgesen in Vidensk. Meddel. naturh. Foren. Köbnhavn. 1908, p. 28, fig. 1, from the Danish West Indies, is in our opinion not *Chlorodesmis comosa* Bail. & Harv., but differs from that species in having having its filaments much longer, somewhat thicker, very thin-walled, only slightly branched and entirely destitute of the characteristic constrictions of the true *C. comosa*. Moreover the rhizoids figured by Dr. Börgesen (loc. cit.) are long and 2—3 times dichotomously branched, recalling those of *Udotea*, and are quite different from the simple rhizoids found in *C. comosa* Bail. & Harv.. This latter species appears to be confined to the Pacific and Indian Oceans.

Whether Dr. Börgesen's plant could possibly be conspecific with the *C. comosa* of Mazé & Schramm (Guadeloupe: Mazé n° 338), discussed above, is a question which we are quite unable to decide. The long thin-walled slightly branched filaments, destitute of constrictions, characterise both plants; and both occur in the West Indies. A comparison of alcohol-material is desirable [1]).

1) While these sheets are passing through the press, we hear from Dr. Börgesen, that he has determined the *Chlorodesmis comosa* of Crouan and Mazé & Schramm in Herb. Mus. Paris to be *Vaucheria dichotoma* (L.) Ag. ♂, and considers it to be identical with his own *Avrainvillea comosa* from the Danish West Indies.

2 *Chlorodesmis minor* Zanardini

in Flora LVII. 1874 p. 500.

Hab. Lyons Reef, Lord Howe Island. *Boldrey* and *Lind.*

Filaments rather thick, flaccid, intensely green, obtuse at apices, at length filled with orange reddish contents.

ZANARDINI states that he compared this species with specimens of *C. comosa* from New Caledonia and found it to differ in possessing filaments more than twice as thick as those of *C. comosa*, flaccid rather than tending to rigidity, and green rather than fusco-nigrescent.

We have seen no specimen of this plant.

3 *Chlorodesmis Hildebrandtii* n. sp.

Syn. *Chlorodesmis comosa* Hauck in Hedwigia XXVII. 1888 p. 92.
Chlorodesmus caespitosa Murray & Boodle in Journal of Botany XXVII. 1889, p. 71 pro parte.

Hab. INDIC. Comoro Islands, Johanna, Pomona (just below lowest tide-level) Aug. 1875. *Hildebrandt* exsicc. n° 59!
Siboga Expedition. Stat. 213. Saleyer Island, reef!

Plant about 6 cm. high, gregarious, tufted, arising from a small felted base, flavescent-green, filaments decumbent below, colourless and much and irregularly branched, producing lateral stolons and rhizoids; filaments ascending above, green, cylindrical, straight, flaccid, up to 6 cm. long, 80—130 μ in diameter, distantly dichotomously branched, the resulting pair of branchlets being constricted once immediately above the dichotomy, and at *equal* distances above it. [Figs. 74, 75].

This plant, referred to *C. comosa* by HAUCK, was transferred by MURRAY and BOODLE to *C. caespitosa* (see p. 62), but differs from both these species. From *C. comosa*, which it resembles much in habit, it differs in its *even* constrictions placed immediately above each dichotomy of the upper filaments (Pl. VIII, fig. 74*c*). And from *C. caespitosa* (our *Rhipidodesmis*) it differs entirely in the mode of ramification of its upper filaments.

The Siboga specimen from Saleyer reef agrees with HILDEBRANDT's plant in having *even* supra-dichotomial constrictions, but apparently differs in having wider-angled dichotomies fig. 75*c*. But as HILDEBRANDT's specimens are dried material and do not recover their normal shape we cannot determine what the dichotomial angle would be in fresh plants.

The distribution so far as is known is confined to the Indian Ocean.

2. Avrainvillea Decaisne.

(Figs. 76—117).

Historical.

The earliest species of which we are aware is a small specimen of *A. Mazei* collected by MARK CATESBY in the Bahama Islands between the years 1722 and 1726. It is preserved

in the Sloane Herbarium in the British Museum (vol. 232, fol. 18), and was described in MS. by SOLANDER in the British Museum copy of RAY's Hist. III. Suppl. p. 12 1704 as "Fucus bahamensis flabelliformis" — a diagnosis which also includes *Udotea flabellum*.

The next species of which we can find any record was published in 1823 by C. A. AGARDH (Spec. Alg. p. 401) as "? *Anadyomene obscura*", collected by GAUDICHAUD in Guham, one of the Marianne Islands. It was transferred in 1887 to *Avrainvillea* by the late J. G. AGARDH (Till Alg. Syst. V. p. 53), in whose herbarium at Lund it is preserved. We have not been able to examine the actual specimens and are therefore in some doubt as to whether it may not prove to be synonymous with *A. erecta*, in which case its specific name would take precedence of *erecta* (see p. 33).

Nineteen years later (1842) two French authors, DECAISNE and CHAUVIN, working independently upon the Polypiers Calcifères (calcareous algae) to determine conclusively their vegetable or animal nature, which theretofore had been a disputed question, published their respective results within a few months of one another, DECAISNE's publication (Ann. Sci. Nat. 2me sér. tom. XVIII. 1842. p. 107) appearing first, as is acknowledged by CHAUVIN in a footnote. Inter alia, DECAISNE described his new genus *Avrainvillea*, with one species *A. nigricans*, collected by D'AVRAINVILLE in the Iles des Saintes, Guadeloupe. The type of this is now in Herb. Mus. Paris. CHAUVIN (Recherches . . ., Caen, 1842, p. 124), who arrived at conclusions similar to those of DECAISNE as confirming the vegetable nature of the Polypiers calcifères, also defined a new genus, which he named *Fradelia* and founded upon *F. fuliginosa*, an alga collected at Pernambuco by FRADEL ("sur le récif de Pernambouc"). His description of it and his remarks are so clear as to justify its being placed under *A. nigricans* Decaisne, notwithstanding the vast distance which intervenes between the respective stations of *Fradelia* and *A. nigricans*, amounting to over 2000 miles. The question of its actual identity can only be settled by an examination of the type, for CHAUVIN omitted to give the diameter of the filaments.

In the same year (1842) BERKELEY (Hooker's London Journal of Botany I. p. 157) described as a fungus in the genus *Dichonema*, calling it *D. erectum*, the plant n° 2234 collected by CUMING in the Philippine Islands. The figure of it is bad, but was sufficient to lead us to suspect that it must be the same as the *Udotea sordida* described by MONTAGNE (Hooker's London Journal of Botany III. 1844 p. 659) two years later from CUMING's n° 2233. Our suspicion proved correct. Further notes on this point are given under *Avrainvillea erecta* (p. 30). This latter species has hitherto been best known under the name of *A. papuana* Murr. & Bood.

In 1857, MONTAGNE (in Ann. Sci. Nat. vol. VII. 1857 p. 136) described *Udotea amadelpha*, a unique specimen collected by LE DUC at the island of Galega in the western Indian Ocean. This species remained in neglect until we gathered together material for the present paper and found the type specimen to possess the structure of *Avrainvillea* and not of *Udotea*. More recently we have found other examples of the plant in the collections of Mr. J. STANLEY GARDINER from the western islands of the Indian Ocean, as we have lately recorded in Trans. Linn. Soc. (Bot.) VII. 1908 p. 178 and further we have no doubt at all that the Red Sea

plant described and figured in 1858 by ZANARDINI (in Mem. Ist. Veneto VII. p. 290 tab. VIII, fig. 1) as *Chloroplegma viridium* is conspecific with *Avrainvillea amadelpha*.

Chloroplegma viridium was the type, and for twenty years the only species, of ZANARDINI's *Chloroplegma*, which is thus merely a synonym of *Avrainvillea*.

In the same year (1858) KÜTZING published (Tab. Phyc. VIII. p. 13, tab. 28) his genus *Rhipilia*, in which he placed two species *R. tomentosa* and *R. longicaulis*, both found in the West Indies. So far as the former species is concerned, the genus *Rhipilia* holds good; but *R. longicaulis* is a species of *Avrainvillea*, and though it has been referred first to one and then to another West Indian species, we are strongly of opinion that it is identical with a third species — *A. sordida* (p. 41). In 1874, DICKIE (in Journ. Linn. Soc. (Bot.) XIV. p. 151) added to *Rhipilia* another species, *R. Rawsoni* from Barbados, subsequently placed by MURRAY and BOODLE (1880) in *Avrainvillea* as a synonym of one of the species, but recently shown to be a good species by Dr. HOWE, namely *A. Rawsoni*.

Chloroplegma papuanum ZANARDINI (1878), *Chlorodesmis pachypus* KJELLMAN (1879—80), *Rhipilia Andersonii* MURRAY (1880), and *Avrainvillea papuana* MURRAY & BOODLE are all synonymous with *A. erecta*, mentioned above.

In 1887, J. G. AGARDH (Till Alg. Syst. V. p. 84) supplied a description to *Avrainvillea lacerata*, a species which had been issued several years previously without description by HARVEY in his Friendly Islands Exsiccatae as *Udotea lacerata*.

The only attempt hitherto made to monograph the genus was that of MURRAY and BOODLE in 1880 (in Journ. of Botany XXVII pp. 67—72, 97—101), in which they gave a history of the genus, a systematic arrangement of the species, and an account of the structure. They recognise seven species of *Avrainvillea* and also include in the genus *Chlorodesmis comosa*, and with some reservation, *C. caespitosa* — an arrangement of which we do not ourselves approve.

In 1905 and 1907 Dr. HOWE (in Bull. Torrey Bot. Club XXXII. p. 565; XXXIV. p. 507) has treated of the West Indian species, recognising four species which he carefully describes and some which he figures. He also gives an account (op. cit. XXXIV p. 504) of the sporangia of *Avrainvillea nigricans* f. *fulva* which he had the good fortune to find on a specimen gathered in Montego Bay in January 1907. The spores, few in number, are contained in the inflated ends of filaments which project from the surface of the frond. Since his account was published we have ourselves noticed similar sporangia, but void of spores, in typical *A. nigricans* from Grenada and in a form of *A. erecta* collected by THURSTON in the Gulf of Manaar, Madras, the specimen being preserved in alcohol in the British Museum.

We have found it necessary during our present study of the genus to establish five new species from the following localities — Port Phillip and Christmas Island in the Indian Ocean, Fiji Islands and elsewhere in the Pacific Ocean, Canary Islands and Grenada in the Atlantic.

The most constant characters for distinguishing the species of *Avrainvillea* we have found to be the size and nature of the filaments composing the frond, whether cylindric, torulose or moniliform, whether isodiametric or tapering towards the apices, whether tortuous or straight, and their mode of ramification. These characters, coloured. For the proper appreciation and comparison of these data it

is almost indispensable to make drawings to a uniform scale, by means of the camera lucida, of the frond filaments of almost every specimen examined. But owing to the collapsed state in which the filaments are often found in dried material, especially when the plants have been subjected to heavy crushing pressure by the zealous but misguided collector, it is usually advisable to submit the filaments to such a treatment as the following. First soak the fragment of frond in spirit for a few seconds, then in water for half an hour, then in lacto-phenol (warmed) for about half to one hour (or boil in lacto-phenol on slide), replace in water and tease asunder the filaments under a dissecting microscope. This treatment will in many cases go far towards restoring the filaments and will generally facilitate the teasing of them apart.

Under the name of "*Aurainvillea* spec." Prof. Oltmanns (Morph. und Biol. d. Algen I. 1904 p. 292, fig. 179; II. 1905 p. 278, fig. 538) has represented a remarkable plant (sine loc.; comm. G. Karsten), which we regret that we are unable to recognise. Its frond is not flabelliform, but cylindric in outline and apparently composed of loose spreading filaments. The stipes recalls that of *Avrainvillea*; but the frond or capitulum is a puzzle. We can only suggest that it might possibly be an abnormal form of *A. erecta*, a species which, as Ferguson's specimens from Ceylon show, sometimes assumes abnormal shapes and has a fringed margin. Possibly Prof. Oltmanns' plant is one which has undergone regeneration after injury, for example, after the loss of the frond (see p. 32).

Avrainvillea Decaisne

in Ann. Sci. Nat. Bot. 2me Sér. XVIII. 1842. p. 108.

Syn. *Fradelia* Chauvin Recherches ... Caen 1842. p. 124.
Chloroplegma Zanardini in Mem. Ist. Veneto. VII. 1858. p. 290.
Avrainvillea J. G. Agardh Till Alg. Syst. V. 1887. p. 51.
Avrainvillea Murray & Boodle in Journ. of Bot. 1889. p. 67. (*excl. Chlorodesmis*).
Avrainvillea De Toni Syll. Alg. I. 1889. p. 513.
Aurainvillea Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil. 1890. p. 141.
Avrainvillea Howe in Bull. Torrey Bot. Club XXXIV. 1907. p. 508.
Avrainvillea Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 389.
Avrainvillea Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil. Nachträge. 1910. p. 128 (*excl. Chlorodesmis*).

Plant uncalcified, fusco-nigrescent, green to olivaceous or fulvous, usually flabelliform and stipitate, rarely eflabellate and composed of clavate or difform lobes (*A. Rawsoni*).

Rhizoids tufted, forming a bulbous mass or sometimes a creeping or ascending or erect rhizome.

Stipes simple, forked, or more divided, short to long, sometimes much abbreviated, stout or slender, terete or flattened.

Frond of varied shape (even in the same species), more or less rotundate to flabelliform or cuneate, at base cordate or truncate to cuneate, rarely palmate or digitate, thick to thin, sometimes zonate, margin entire to eroded or lacerate or lobed.

Frond filaments varying in size, colour, and form, but usually fairly uniform for the species and almost always characteristic of it, dichotomously branched, constricted at dichotomies,

cylindric to torulose or moniliform, about 20—70 μ in diam., often tapering towards apices (apices felted into a pseudocortex in *A. amadelpha* and *A. asarifolia*), without fibulae or lateral branchlets; colour varying from pallid to deep-orange or brown.

Sporangia "terminal on filaments exserted from surface of flabellum, containing a few (1—8) spores (aplanospores)" (M. A. Howe loc. cit.).

"A tropical genus of coarse, unsightly algae, growing abundantly in muddy shallow water, but extending also to considerable depths". (Collins loc. cit.).

Synopsis of Species.

Thallus never developing a true flabellum, but forming more or less digitate, capitate or difform lobes, fuscous to nigrescent. Filaments 28—68 μ in diam., thin-walled, mostly torulose and pallid, here and there dark brown. . . . . *A. Rawsoni* (p. 22).

[Note. Subflabellate forms are also found in *A. Ridleyi* and *A. amadelpha* f. *Montagneana*].

Thallus developing one or more flabellate fronds.

Filaments 40—70 μ, often tapering down to 20 μ at their branched apices, distinctly moniliform and pale to dark brown. Rhizome horizontal, stout; frond fuscous, either small thick cuneate (f. *fulva*), or stipitate, large to very large . . . . . *A. nigricans* (p. 23).

Filaments 40—60 μ, not tapering, cylindrical, strongly constricted above dichotomy, often deep orange brown. Frond usually longly stipitate, large, brown. . . . . *A. Mazei* (p. 27).

Filaments 30—60 μ, not tapering, cylindrical, strongly constricted above dichotomy, yellow to intensely fulvous. Frond shortly stipitate to subsessile, small or large, brown with a tinge of yellow in it . . . . . *A. erecta* (p. 29).

Filaments usually 40—60 μ, ultimate ramuli about 30 μ increasing to 50 μ at their clavate apices, cylindrical, stated to be green. Frond stipitate, small, widely cuneate . . . . . *A. obscura* (p. 32).

Filaments 35—55 μ, ultimate ramuli about 35—40 μ, gradually increasing to 50—55 μ at their clavate apices, often torulose, with dense green, sometimes orange contents. Frond stipitate, cuneato-flabellate, medium size, green . . . . . *A. clavatiramea* (p. 33).

Filaments 25—35 μ, usually torulose but sometimes more or less cylindric, with pale brown contents, here and there dense brown, ultimate ramuli sometimes subclavate. Fronds short, brown, congregated on a thickened base, thick, difform, often concrescent, here and there divided, flabella absent or eroded . . . . . *A. Ridleyi* (p. 33).

Filaments 30—40 μ, not tapering, not clavate, here and there torulose, green to fulvous brown, but often collapsed and colourless. Rhizome erect. Frond large brownish-green, rotundate, cuneate at base, very obscurely zonate . . . . . *A. canariensis* (p. 34).

Filaments 20—30 μ, rarely 15 μ at apices, cylindrical, sometimes slightly torulose, either colourless or full of brown contents. Rhizome erect. Frond medium size, brown, stipitate, irregular, zonate, eroded above, sometimes lobed. . . . . *A. Elliottii* (p. 35).

Filaments 20—30 μ, not tapering, markedly torulose, colourless with sparse green contents, sometimes stained pale brown; apices slightly tortuous, free. Rhizome suberect, long, stout. Frond very large, zonate, green . . . . . *A. Gardineri* (p. 36).

Filaments 25—6 μ, tapering, markedly torulose, colourless with sparse green contents, sometimes stained pale brown; apices tortuous or hooked. Rhizome stout, bearing two or more fronds. Frond shortly stipitate, medium size, brown . . . . . *A. pacifica* (p. 37).

Filaments 25—6 μ, tapering, cylindrical; apices often slightly torulose, generally not tortuous; filaments of interior often yellowish-brown. Fronds many and arising from a common base . . . *A. lacerata* (p. 38).

a. Fronds small, thin, cuneato-obovate, lacerate, green, borne on slender stalks . . . . . forma *typica*.

b. Fronds crowded, cordato-rotundate, subsessile, stouter, larger, usually entire, brown, subsessile . . . . . forma *robustior*.

Filaments 35—6 μ, tapering, cylindrical, here and there torulose, rarely submoniliform, yellow to dark brown, not or very slightly tortuous at apices. Plant subsimple, cinereous. Frond stipitate, of medium size, subrotundate . . . . . *A. sordida* (p. 40).

Filaments 25—15 μ, rarely tapering to 6 μ, torulose towards apices, which are very tortuous, branched, irregularly swollen, hooked and felted together into a pseudo-cortex. Rhizome stout, bearing a few or many fronds on branched stipites. Frond green or brown. *A. amadelpha* (p. 42).

a. Fronds short, numerous, densely congregated on a thickened base, thick, much eroded . . . . . forma *Montagneana*.

b. Fronds few, large, entire, subrhomboid-rotundate, with cuneate to rounded base. Stipes long, branched . forma *submersa*.

Filaments 30—20 μ, tapering to 15 μ or 10 μ torulose towards apices, which are very tortuous, branched, irregularly swollen, felted together into a pseudo-cortex. Plant simple, dark olive-green to greyish. Frond large, thin, oblong-reniform with cordate base, entire, zonate. Stipes long, simple. . . . . *A. asarifolia* (p. 44).

1. *Arainvillea Rawsoni* Howe

in Bull. Torr. Bot. Club XXXIV. 1907. p. 511, tab. XXX.

Syn. *Microdictyon Rawsoni* Dickie in Journ. Linn. Soc. Bot. XIV. 1874. p. 151 tab. XI, fig. 1, 2.
Arainvillea nigricans Marc et Schramm Algues de la Guadeloupe 1870—77. p. 89.
Arainvillea nigricans Murray & Boodle in Journ. of Bot. XXVII. 1889. p. 70 (pro parte).
Arainvillea nigricans Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Arainvillea nigricans De Toni Syll. Alg. I. 1889. p. 513 (pro parte).
Arainvillea Rawsoni Collins, Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 390.

Hab. ATLANTIC: Barbados, *Rawson* in Herb. Mus. Brit.! — *Rawson & Watts* (Herb. Dickie)! — Jamaica, Montego Bay, *Pease & Butler*, Phyc. Bor. Amer. 771! — Guadeloupe, Gosier, *Mazé* n° 400 (in Herb. Mus. Brit. and Herb. Kew)! — Marie-Galante, *Mazé* n° 1200 (in Herb. Mus. Brit.)! — Moule, Porte d'enfer, *Mazé* n° 175, 1ere sér. (in Herb. Kew)! — Bahamas, Berry Islands, Frozen Cay, Jan. 30. 1905, on rocks at low water mark, *Howe* n° 3572 (in Herb. Kew)! — Bahamas, Mariguana, Abraham Bay, *Howe* in Phyc. Bor. Amer. n° 1481!

"Mostly bright or sordid-green when living, becoming fuscous-brown or nigrescent on drying, forming caespitose masses with usually crowded, sub-terete, fusiform, clavate, or finger-shaped, sometimes capitate, often difform, branched, and anastomosing lobes, never developing a flabellum; lobes azonate mostly 4—12 cm. long and 0.5—4.0 cm. in diameter, now and then disappearing in irregular cushions by fusing, the surface velutinous, spongiose, or sub-strigose: filaments of the lobes subtorulose or the inner cylindrical with occasional constrictions, always strongly constricted just above the dichotomy, rather thin-walled and somewhat easily collapsible, 28—68 μ in diameter." M. A. Howe in Bull. Torr. Bot. Club XXXIV. 1907 p. 511. [Figs. 76, 77].

We have availed ourselves of Dr. Howe's excellent description of this species. He has had the opportunity of studying the plants in the living state and he says that they never develop a true flabellum. Among the flabellate species the nearest allies of *A. Rawsoni*, as regards structure and size of filaments, are *A. Mazei* and *A. nigricans*. It differs from *A. Mazei* in having its filaments mostly torulose and with thinner walls; and from *A. nigricans* in being thin-walled, mostly pallid and merely torulose, never moniliform, and never markedly tapering nor repeatedly dichotomous at their apices.

When examining the frond-filaments of *A. Rawsoni*, we have often noticed the presence of dark coagulated plugs (see fig. 77) in the constrictions above the dichotomies; and since we have not observed them in the vegetative frond-filaments of any other species, we are tempted to regard them as a character of specific value in *A. Rawsoni*. Further their presence seems to be correlated with the fact that the natural (original) apices of the filaments are generally broken off. We therefore infer either (1) that these stoppers serve to plug the filaments left open by the fallen (nibbled?) apices and so to arrest the escape of the protoplasm from the broken ends, or (2) that they are mere blockages which have become accidentally fixed in the constrictions and have thereby caused the death and decay of the filament above. But inasmuch as we can see no obvious reason why such a blockage should cause the death of a young filament well provided with protoplasm and chromatophores, we are of opinion that the first alternative is the more probable explanation. Plugs of similar function are found at

the base of old sporangiophores in several species, and in the rhizome-filaments of *A. nigricans*.

The distribution of *A. Rawsoni* is confined to the West Indian region.

2. *Avrainvillea nigricans* Decaisne

in Ann. Sci. Nat. 2me sér. vol. 18. 1842 p. 108.

Syn. *Fradelia fuliginosa* Chauvin, Recherches —, Caen 1842. p. 124.
Avrainvillea sordida var. *longipes* Crouan ex Mazé et Schramm Algues de la Guadeloupe. 2me édition. 1870—77. p. 90 (pro parte).
Rhipilia longicaulis Dickie in Journ. Linn. Soc. (Bot.) XIV. 1874. p. 312.
Avrainvillea nigricans J. G. Agardh Till Alg. Syst. V. 1887. p. 53.
Avrainvillea nigricans Murray & Boodle in Journ. of Bot. XXVII. 1889. p. 70 (pro parte).
Avrainvillea longicaulis Murray & Boodle in op. cit. p. 70 (pro parte), tab. 228, figs. 1—5.
Avrainvillea nigricans Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Avrainvillea longicaulis Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Avrainvillea nigricans De Toni Syll. Alg. I. 1889. p. 513 (pro parte).
Avrainvillea longicaulis De Toni Syll. Alg. I. 1889. p. 514 (pro parte).
Avrainvillea nigricans Howe in Bull. Torrey Bot. Club XXXIV. 1907. p. 509.
Avrainvillea nigricans Börgesen in Vid. Medd. nat. Foren. Kjöbnhavn 1908. p. 30.
Avrainvillea nigricans Vickers & Shaw Phycologia Barbadensis. Paris 1908. p. 23, pl. XXX.
Avrainvillea longicaulis Vickers & Shaw op. cit. p. 23, pl. XXXI.
Avrainvillea nigricans Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 390.

Hab. ATLANTIC. Guadeloupe, Iles des Saintes, *d'Avrainville*! — Point à Pitre, Ilet à Jarry, *Mazé* n° 174 *bis* in Herb. Mus. Brit! also n° 174 and 174 *bis* in Herb. Kew! — Saintes, anses du vent, sur la coquille d'un Strombus, *Mazé* n° 1126 (sub nom. "*Avrainvillea sordida* var. *longipes*") — Florida, Caesar's Creek, in mangrove mud, near low-water mark, *M. A. Howe* n° 2963 in Herb. Kew! — Bahamas, Cave Cays, Exuma Chain, *M. A. Howe* n° 3982, in Herb. Kew! and Great Guana Cay, Exuma Chain, *M. A. Howe* n° 4052, in Herb. Kew! and New Providence, *M. A. Howe* n° 3335, in Herb. Kew! — St. Thomas, "*Challenger*" Expedition, 5—15 fathoms in Herb. Mus. Brit! and Kew! — Antilles, *Herb. Shuttleworth*! — Jamaica, Montego Bay, *Pease & Butler*, Phyc. Bot. Amer. n° 770, in Herb. Mus. Brit! — Barbados, Bath, *Vickers* n° 40 (sub nom. *A. longicaulis*)! — Brazil, Pernambuco, *Fradel*? — Bermuda, "*Challenger*" Expedition, sub nom. *Rhipilia longicaulis*, Dickie in Herb. Kew!

"Usually fusco-nigrescent when living or rarely tawny-green, of a similiar colour on "drying or somewhat darker or more sordid, gregarious or scattered, normally with a stout "horizontal rhizome (commonly left in substratum as ordinarily collected), or, when small and "poorly developed, with a somewhat bulbous or difform base: stipe cylindrical or flattened, "1—16 cm. long, 3—14 mm. wide, now and then deficient or scarcely differentiated, simple or "rarely forked near the base: flabellum varying from suborbicular (reniform-cordate when young) "to cuneiform (sometimes subclavate when young), 1—25 cm. broad, entire or more or less "lacerately or digitately lobed, thin and membranous in the broader forms, thicker and more "coriaceous in the narrower, felt-like in texture, very obscurely or not at all zonate, the surface "subvelutinous or minutely spongiose: filaments of flabellum distinctly moniliform or torulose "(at least those near the surface) usually firm-walled and rather straight and rigid, 33—70 μ "in maximum diameter, filaments of stipe similar, but with more differentiation between those "of surface and those of interior: sporangia mostly subpyriform, varying from clavate to "subglobose, 0.35—0.83 mm. × 0.20—0.35 mm., usually exserted once or twice their own length;

"spores ovoid, pyriform, or elongate-ellipsoidal, 130—300 μ × 66—120 μ". M. A. Howe in Bull. Torr. Bot. Club XXXIV. 1907. p. 509. Figs. 78—80.

The foregoing is a verbatim copy of Dr. Howe's excellent description. The species is very variable in external form and size; and though it may generally be recognised by the moniliform character and large size of its frond-filaments, yet even in these filaments there is considerable variation, viz., in diameter, acropetal tapering, terminal branching, degree of constriction between the bead-like swellings, shape of these swellings (whether nearly spherical or ellipsoidal), colour of filaments, etc. Indeed there may often be a puzzling variability in one and the same plant. It is difficult on the one hand to define the limits of the species, and on the other to divide the species into readily recognised forms. Dr. Howe, who has handled innumerable living examples in the West Indies, writes as follows: — "one extreme is represented by plants with "a suborbicular flabellum (reniform-cordate when young), reaching a width of 25 cm., supported "by a cylindrical stipe, which has a maximum length, so far as observed, of 16 cm., this "springing from a strongly developed rhizome; the other extreme has a cuneiform flabellum, "sometimes no more than 1—2 cm. wide, tapering gradually to a flattened scarcely recognizable "stipe, with rhizome poorly developed. Between these two extremes there seems to be a "nearly perfect series of intermediates . . . ." (op. cit. XXXII. 1905. p. 568). Both these extremes are included in his specific description given above. But more recently he has applied the name of forma *fulva* to the second extreme (the cuneate form) and issued specimens with a description in Collins, Holden and Setchell's Phycotheca Boreali-Americana under no. 1480. The description runs as follows: —

"*Avrainvillea nigricans fulva* M. A. Howe, forma nova. Differs from the typical form "of *A. nigricans* in its thicker more spongiose and usually more cuneate flabellum, in its flatter, "broader, less differentiated stipe, and in the firmer-walled, usually coarser though often more "tapering filaments, which are less regularly moniliform, often more tortuous or zig-zag, more "frequently and more divaricately dichotomous, and nearly always yellow or yellowish brown rather than fuscous at maturity.

"Common in 3—10 dm. of water, inside a reef, Castle Island, Bahamas, Dec. 22. 1907.

"New York Botanical Garden Expedition to the Bahamas, collected by Marshall A. Howe.

"The present form is rather common in the West Indies and by a certain combination "of characters is thus far readily distinguishable from the typical *A. nigricans*, in association "with which it sometimes grows, yet it seems difficult to point out any one character by "which it may be always recognized, or even any combination of characters which can be "described in sufficiently precise terms for specific distinction. The Jamaican plant of which "the supposed sporangia were recently described and figured (Bull. Torr. Bot. Club, vol. "XXIV, pp. 504—507, pl. XXVIII, figs. 8—25, 1907) belongs to forma *fulva* and the form "has been included in our previous descriptions of the extremely variable *A. nigricans* (Bull. "Torr. Bot. Club, vol. XXXII, p. 508, 1905; vol. XXXIV, p. 508, 1907)".

In the British Museum is a bottle of spirit-specimens collected in Morne Rouge Bay, Grenada, by the late W. R. Elliott, which answer to Mr. Howe's description of f. *fulva* as

regards external characters, being mostly short, thick, spongy and cuneate, many of them without marked differentiation into stipes and frond, but some of them distinctly stipitate; and the frond-filaments are coarse (up to nearly 70 μ) lightly constricted, tapering down to 20 μ at the apices, but not tortuous nor zig-zag, nor more than about twice branched at the apices. Nor are the filaments of a fulvous colour, but mostly hyaline, dotted with chromatophores, and only here and there containing brown (rarely fulvous) contents. Those plants however on account of their external character are probably referable to f. *fulva*.

As regards the rest of the specimens of *A. nigricans*, they are so perplexing in their variability, that it seems quite impossible to separate them into satisfactory groups. Some plants are very large with wide thin flabellum, thick coarse rhizome, and frond filaments of 60 μ diam. and tapering down to 20 μ at their divaricately ramified apices. These large plants appear to be of common occurrence, ranging at least from St. Thomas to Grenada. Others again are quite small and slender, and among these is DECAISNE's type-plant. DECAISNE's type is preserved in the Paris Museum and bears his label "*Avrainvillea nigra* Dne. Iles des Saintes près la Guadeloupe. M. D'AVRAINVILLE. 1842". Thanks to Monsieur HARIOT's kindness, we are able to give a figure of it (fig. 78). It is a small blackish plant about 7 cm. in length including the slender rhizome; it is composed of moniliform filaments, the spherico-oval beads of which have a diameter of about 45 μ tapering down to about 25 μ at the slightly branched apices (fig. 79). The frond is faintly zonate. A descriptive note of the specimen has been published by Dr. HOWE (Bull. Torr. Bot. Club XXXII. 1905 p. 567).

DECAISNE's plant is quite unlike the above-mentioned large ungainly specimens with thick coarse rhizome and wide thin flabellum from St. Thomas ("*Challenger*" Expedition) and from Grenada (MURRAY).

In the British Museum is another specimen from Iles des Saintes (the type-locality), viz. MAZÉ's n° 1126. This is a large plant (16 cm. high, stipes 7.5 cm. long, frond 10 cm. broad) collected without a rhizome. It is in fact about as large as the "*Challenger*" specimens, but is composed of rather narrower filaments (35 μ diam.), than those of the type, and only half as thick as those of the "*Challenger*" specimens. In fact it seems as if size of plant and size of filament in this species vary quite irrespectively of one another. Of the big plants some have large, some have small filaments. Even so with the small plants.

Again, in some plants the filaments branch dichotomously 1—4 times in quick succession at their apices; and this is accompanied by a marked tapering in some, but not in others. Thus a filament with a diameter of 60 μ rapidly divides into branchlets tapering down to 20 μ. These ultimate ramuli, by interweaving with one another, form a stronger protective layer on the surface of the frond. We do not however know whether the presence or absence of this branching and tapering is dependent on seasonal changes, or upon the depth at which the plants grow beneath the surface of the sea; or whether it is proper to some plants and not to others, and therefore is capable of being employed as a systematic character. We do not know the length of life of these plants, how soon they reach maturity, whether they endure for a few or many months, whether after producing their numerous but inconspicuous sporangia they wilt away. These are questions which cannot be solved in a herbarium.

Dr Borgesen (in Vid. Medd. Nat. Foren. Kjobnhavn 1908. p. 30), who has collected these plants extensively in the Danish West Indies from depths of 20—30 meters, finds the species to be easily distinguishable by the very loose texture of the flabellum, and by its translucency when held up to the light. He also describes and figures the chromatophores as spindle shaped. This does not accord with our observations, for in all the specimens of *A. nigricans* in which we could detect the chromatophores, we found them to be round without exception.

The colour of the dried plants varies from brown to greyish or blackish brown. The colour of the filaments varies from pale to dark cool brown, but sometimes is more fulvous. In all the spirit specimens which we have examined the filaments are colourless, dotted with round chromatophores, and only here and there stuffed with brown (rarely fulvous) contents. It would seem that the general brown stain of the filaments, which is preserved in the dried plants, has been removed from the pickled specimens by the action of the alcohol or picric-alcohol.

The sporangia of *A. nigricans* were discovered and described by Dr. Howe (Bull. Torr. Bot. Club XXXIV. 1907. pp. 504—507) upon a plant which he refers to his forma *fulva*. He describes them as capitate or subclavate filaments, protruding abundantly from the surface of the thallus, the sporangia being half as long as the supporting stalk. They were intensely green when young, brown when older; and they contained about 3—5 ovoid, pyriform, elongate-ellipsoidal, or difform bodies, which he concluded were probably aplanospores. The sporangiophores arise dichotomously, though sometimes appearing lateral, and are often more slender than the vegetative filaments from which they spring.

We have found sporangia and old sporangiophores on plants of *A. nigricans* collected at Glover's Island, Grenada, by Mr. G. Murray in August 1886, and preserved in alcohol. These plants have large thin fronds and are borne on thick coarse well-developed rhizomes. The sporangia are all empty; they correspond nearly enough in size with those described by Dr. Howe for his forma *fulva*. Similar sporangia occur on a small dried specimen "ex Antillis" in Herb. Shuttleworth in Herb. Mus. Brit.

A. nigricans can be classed with *A. Rawsoni* and *A. Mazei* in the large size of its filaments. It differs however from *A. Rawsoni* in having its filaments less thin-walled and usually more deeply and moniliformly constricted, and in the possession of a more or less flabellate frond. From *A. Mazei* it differs in having moniliform filaments; those of *A. Mazei* are cylindric.

A short note is necessary about a Jamaican specimen in the British Museum, namely n° 770 of the Phycotheca Bor.-Amer., issued as *A. longicaulis*. It is undoubtedly *A. nigricans*, but is a queer rhizomatous plant, which appears to have suffered injury twice and to have put out proliferations each time. One of these proliferations is a stipitate spathulate flabellum, with the structure of *A. nigricans*. One of the other outgrowths looks like a little proliferation, but cannot be so, because it has the structure of *A. Rawsoni*. It must therefore be a plantlet of *A. Rawsoni* which has developed epiphytically on the rhizome of the bigger plant. It should be added that Mr. Howe (in Bull. Torrey Bot. Club XXX. 1907. p. 511) says that he has examined n° 770 in three sets and found them all, as well as n° 771, to be *A. Rawsoni* "though it does not the material issued under n° 770 is mixed with *A. nigricans*."

We have seen no specimen of *Fradelia fuliginosa*, but in view of Chauvin's excellent description and remarks (loc. cit.) we recognise the strong likeness of the plant to *A. nigricans* which was published by Decaisne a few months previously (see p. 17); but of course without examining the type we cannot be certain of the identity of the plant, since Chauvin omitted to state the size of the filaments; and it must not be forgotten that Fradel's plant was collected at Pernambuco more than 2000 miles away from Grenada, the nearest recorded station of *A. nigricans*.

A. nigricans is recorded only from the warm Atlantic.

3. *Avrainvillea Mazei* Murray and Boodle

in Journal of Botany XXVII. 1889 pp. 70, 71, tab. 288, fig. 6.

Syn. *Flabellaria fimbriata* Mazé et Schramm Algues de la Guadeloupe. 2me edit. 1870—77. p. 89; and Errata p. 11.
Avrainvillea sordida var. *longipes* Crouan ex Mazé et Schramm Algues de la Guadeloupe. 2me edit. 1870—77. p. 90 (pro parte).
Udotea Desfontainii J. G. Agardh Till Alg. Syst. V. 1887. p. 74 (pro parte).
Avrainvillea Mazei Murray in Journ. of Bot. XXVII. 1889. p. 238.
Avrainvillea Mazei De Toni Syll. Alg. I. 1889. p. 514.
Avrainvillea longicaulis Howe in Bull. Torrey Bot. Club. XXXIV. 1907. p. 509 (excluding synon. *Rhipilia longicaulis* Kütz.).
Avrainvillea Mazei Börgesen in Vid. Medd. nat. Foren. Kjöbnhavn. 1908. p. 32.
Avrainvillea longicaulis Collins Green Algae N. Amer. in Tufts College Studies II. 1909. p. 391.

Hab. Atlantic. Guadeloupe, Moule (Vieux bourg) port; dans le sable sur des bancs de Zostera, lieux abrités par les brisants du large; en Juin 62; leg. Schramm: *Mazé* n° 65, 1ère sér. (sub nom. "*Flabellaria fimbriata*")! — Guadeloupe, Marie Galante (Grand Bourg) plage des Basses, 21 février 1870, *Mazé* n° 1234 (sub nom. "*Avrainvillea sordida* var. *longipes*")! — Bahamas, *Catesby* in Herb. Sloane vol. 232, fol. 18! (see p. 16) — Bahamas, Waterloo Lake near Nassau, April 9. 1904, in mangrove mud, near low water mark. *Howe* n° 3073 (in Herb. Kew)! — Bahamas, Mariguana, *Howe*, in Phyc. Bor. Amer. n° 1479! — Bermuda, Gibbet Island, on rocks and sand in 3 dm. of water (low tide). *Howe* n° 35 (this specimen contains intrusive torulose filaments of another species *A. nigricans*)!

Plant (dried) brown, about 13 cm. high, gregarious or solitary, arising from a bulbous base. Stipes simple, straight, compressed, 5—6 cm. long, 5—10 mm. wide. Frond from a short cuneato-rotundate base, obovate, rotundate or spathulate, about 6 cm. long, 5 cm. wide, of medium thickness, ezonate, rather smooth to strigose. Frond filaments cylindrical, rarely faintly sub-torulose, large, 40—60 μ in diam., light to dark-brown in colour, branches markedly constricted just above the dichotomy, not tapering at apices. [Figs. 81—83].

The above description is drawn from the type specimens of Murray and Boodle, preserved in the British Museum, viz. Mazé's n° 65 (1ère sér.) from Guadeloupe (fig. 81). The characteristic feature of this species is the large cylindrical brown filaments much constricted just above their points of dichotomy, of fairly uniform diameter, not tapering towards their apices (figs. 82, 83).

Dr. Howe (loc. cit.) has combined this species with *Rhipilia longicaulis* Kütz. and placed them both under the designation "*Avrainvillea longicaulis* (Kütz.) Murray and Boodle p.p.",

excluding the description and specimens of Murray and Boodle and retaining nothing more than one of the synonyms cited by them, namely *Rhipilia longicaulis* Kütz., a plant which they had never seen except in Kützing's figure (Tab. Phyc. VIII. tab. 28, II). The numerous specimens collected by Murray, and studied by Murray and Boodle, and described and figured by them as *A. longicaulis* in Journ. Bot. XXVII 1889 p. 70, tab. 288, figs. 1—5, — they, with the specimens Mazé n. 1126 Guadeloupe, and St. Thomas "Challenger", all marked with a "!" by those authors, represent what Murray and Boodle intended to denote by their name *A. longicaulis*. And, as Dr. Howe has rightly shown, these specimens must all be transferred to *A. nigricans* Decaisne (Howe, op. cit. pp. 508, 509). Murray and Boodle blundered in adding *Rhipilia longicaulis* Kütz. as a synonym to their *A. longicaulis*.

It is perfectly clear what Murray and Boodle meant by their *A. longicaulis*, and it is equally clear what they meant by their *A. Mazei*. *A. longicaulis* Murr. & Boodle = *A. nigricans* Decaisne, and *A. Mazei* Murr. & Boodle = *A. longicaulis* Howe (excluding *Rhipilia longicaulis* Kütz.). We say, "excluding *Rhipilia longicaulis* Kütz.", because we cannot agree with Dr. Howe that it is synonymous with *A. Mazei* Murr. & Boodle, at least if Kützing's figure (Tab. Phyc. VIII. p. 13. 1858 tab. 28. fig. II) of his plant is at all accurate as to the character and dimensions of its frond filaments. Kützing states that the branched filament in this drawing is "60 mal vergrössert" and also indicates that magnification on the plate itself. If careful measurements be made, it can easily be calculated that the frond filaments of *R. longicaulis* Kütz. taper (as we state also under our *A. Elliottii*) from about 25 μ at the coloured torulose part (where in dried specimens the normal dimensions of the filament are always best preserved) down to 5 μ at their colourless apices. And further, these dimensions correspond almost exactly with those shown by Dr. Howe to be characteristic of his *A. levis* (Bull. Torrey Bot. Club XXXII. 1905 pp. 565, 566), which is synonymous with the type of the *A. sordida* of Crouan, Mazé & Schramm, and Murray & Boodle. It may be urged that the well-developed rhizome depicted by Kützing is by no means a characteristic of *A. sordida*, but neither is it a character of typical *A. Mazei*. Dr. Howe (Bull. Torrey Bot. Club XXXVII. 1905 p. 586) states in an "Addendum" to his paper that he has examined fragments of the flabellum and stipes of Kützing's *Rhipilia longicaulis*, and adds: — "These indicate clearly, we [Dr. Howe] think, "that the species is the same as the more recently published *Avrainvillea Mazei* Murr. & "Boodle". Dr. Howe gives no measurements of the filaments of that specimen. We are therefore unable to decide whether they correspond with the measurements calculated from Kützing's plate.

Dr. Howe (loc. cit.) continues, "The filaments of the flabellum are now and then "slightly torulose, but they are mostly cylindrical without constrictions, except for the strong "one where they leave the dichotomy; the ends of some of the branches are thin-walled and "shriveled, but they are not destitute of chlorophyll and should not be considered hairs". But this description does not correspond with the partially torulose and apically attenuated filaments of Kützing's description nor with the figure of the enlarged filament in Kützing's plate, in which short coloured lengths of the filament are conspicuously torulose, divide dichotomously and taper into colourless slender terminal ramuli. Thus even if Kützing's magnification

("60 : 1") be wrong, the filaments described and figured would lack the character of the cylindrical, non-tapering, coloured, obtuse filaments of typical *A. Mazei*.

As stated above, the filaments depicted by KÜTZING resemble both in dimensions and in character those of *A. sordida*; and, on the supposition that KÜTZING's rendering and magnification are accurate, we consider *Rhipilia longicaulis* Kütz. to be synonymous with *A. sordida* (p. 40).

Finally, if KÜTZING's plant be really *A. sordida* the puzzle of the so-called hairs ("apice in pilum subtile tenerrimum hyalinum attenuata" Kütz.) is of course explained, since the apical filaments in the frond of *A. sordida* are among the most slender in the genus.

Dr. BÖRGESEN (loc. cit.) has described and figured an *A. Mazei* forma, which we have not seen, but which appears to be an intermediate. It approaches *A. Mazei* in its thicker cylindric inner filaments, and *A. sordida* in its thinner subtorulose surface filaments.

A. Mazei is recorded only from the West Indies.

4. *Avrainvillea erecta* comb. nov.

Syn. *Dichonema erectum* Berkeley in Hooker's London Journal of Botany I. 1842 p. 157, tab. VII, fig. 11 (structura false depicta).
Udotea sordida Mont. in Hooker's London Journal of Botany. III. 1844 p. 659; Syll. Gen. Spec. Crypt. Paris 1856, p. 451.
Chloroplegma papuanum Zanard. in Nuov. Giorn. Bot. Ital. X. 1878. p. 37.
Chlorodesmis pachypus Kjellm. in Wittr. et Nordst. Algae Exsicc. n^0 343 (1879); in Botan. Notiser, 15 Sept. 1880. p. 117.
Rhipilia Andersonii Murray in Trans. Linn. Soc. Bot. ser. II vol. II. 1886 p. 225, tab. 31 (optime depicta).
Rhipidonema erectum Saccardo Syll. Fungorum VI. (1888). p. 689.
Avrainvillea papuana Murray et Boodle in Journ. of Botany XXVII. 1889 p. 71, tab. 289.
Avrainvillea papuana De Toni Syll. Alg. I. 1889. p. 514.
Aurainvillea papuana Heydrich in Ber. deutsch. bot. Gesellsch. XXV. 1907 p. 101.

Hab. INDIC. Sorong, New Guinea, *Beccari*! — Labuan, Borneo, *Kjellman* in Wittr. & Nordstedt Algae Exsicc. n^0 343! — Philippines, *Cuming*, n^0 2234 Herb. Mus. Brit! & Herb. Kew! n^0 2233 Herb. Delessert. — King's Island Bay, Mergui Archipelago, *Anderson*! — Ceylon, *Ferguson*, n^{os} 290! 313! — Pearl Bank, Ceylon, *Herdman*! — Madras, *Thurston*! with fruit.
Siboga Expedition. Stat. 37. Paternoster Islands, 20 m.! — Stat. 71. Makassar, 15 m.! — Stat. 163. Selee-Strait, New Guinea, reef! — Stat. 231. Ambon, reef! — Stat. 261. Great-Kei Island, reef! — Stat. 285. South coast of Timor, 34 m.! — Stat. 296. Noimini Bay, South coast of Timor, reef! — Stat. 299. Buka Bay, Rotti, reef! — Stat. 301. Pepela Bay, Rotti, reef! — Stat. 313. Saleh Bay, Sumbawa, 15—36 m.! — Stat. 323. Sangkapura-roads, Bawean Island, reef!
PACIFIC. Riukiu, *Kuroiwa*, fide Heydrich.

Plant solitary, consisting of a dense stout, cylindrical elongated mass of rootlets, often 10 cm. long, bearing a shortly stipitate or subsessile frond; frond brown, usually small, 3.5—5 cm. wide, sometimes larger (up to 10 cm. wide) reniform to subcuneate-securiform or subrotundate, thin or thick, sometimes obscurely zonate, margin entire or sometimes fibrilloso-fimbriate. Filaments of frond large (30—60 μ) cylindrical, not tapering, never torulose, yellow, often intensely fulvous at their apices. Sporangia terminal on filaments shortly exserted all over the surface of the frond. Spores not seen. [Figs. 84—89].

The earliest specimen of this plant which we have seen and of which we can find any record, is that collected by CUMING in the Philippines and described in 1842 by BERKELEY l. c. as a fungus under the name of *Dichonema erectum*. His description runs as follows: "*Dichonema* "erectum n. sp. olivaceum, erectum, flabelliforme, stipite distincto, margine fimbriato olivaceo-"fusco Cuming n. 2234.

"In sand 1½ inch high, ½ broad, membranaceous, obovato-flabellate, with a distinct "flat stem, olive-green shaded off into olive-brown towards the shortly fimbriate margin. Threads "branched, the branchlets consisting of obtuse moniliform filaments."

Half the specimen which is thus described is preserved in the Herbarium of the Royal Gardens, Kew, and an examination of the structure shews that it is nothing but a small and quite typical plant of what is generally known as *Avrainvillea papuana*.

BERKELEY's figure (l. c.) of the *habit* is quite good, but possibly owing to want of microscopic definition and to the fact that he was examining old and dried material, he has wrongly represented the filaments as being beaded and divided by cross walls. We append a new drawing from his own material in Herb. Kew re-examined by ourselves (fig. 85). BERKELEY's error is perpetuated by SACCARDO in his Sylloge Fungorum VI. 1888 p. 689, and is even increased by the substitution of a false locality in place of that of CUMING, viz:, "*Rhipidonema erectum* Berk. — Surinam (Hostmann)". The explanation of SACCARDO's blunder in allocating BERKELEY's species to "Surinam (Hostmann)" is simple enough. SACCARDO has unwittingly united, and regarded as one, two contiguous papers with similar headings by BERKELEY, namely: — 1. BERKELEY. "Enumeration of Fungi, collected by Dr. HOSTMANN, in Surinam" in Hook. London Journ. of Bot. I. 1842. pp. 138—142). 2. "Enumeration of Fungi, collected by H. CUMING Esq., F.L.S., in the Philippine Islands" (op. cit. pp. 142—157); and SACCARDO has harked back to the prior title on p. 138, as if it covered both papers, — an error which is all the easier as the printers have headed every page of the two papers "Enumeration of Fungi" without distinction.

It will be seen that the n° given by BERKELEY for his *Dichonema erectum* is "CUMING n° 2234" (compare fig. 84); and it is known that BERKELEY shared his set of CUMING's cellular plants with MONTAGNE (see Hooker Lond. Journ. of Bot. III. 1864. p. 659. footnote). Now the next record that we have of this alga is a description of it as *Udotea sordida* by MONTAGNE (l. c.), who quotes as its number "2233 Coll. Delessert". The description, which is founded on a single specimen is as follows: — "Ins. Philippinae. CUMING. 4. *Udotea sordida* Montag. "mss. stipite vix ullo bulboso mox in frondem cuneato-flabelliformem fusco-olivaceam sordidam "obsolete zonatam dilatato. n. 2233 (Coll. Delessert).

"Alga membranacea, cum bulbo stipitiformi uncialis, basi cuneata, semiorbicularis, zonis "obsoletioribus trans lucem praesertim manifestis notata. Structura: fila dichotoma, alia materie "viridi, alia materie fusco-succineo farcta, inter sese maxime intricata. Fructus . . . . . .

"Ab *U. Desfontainii* Dne. colore, structura, nec non defectu stipitis videtur diversa. Descriptio ex unico specimine facta." (MONTAGNE in Hooker's London Journ. of Botany III. 1844. p. 650).

In an editorial footnote to MONTAGNE's paper (l. c. p. 650), it is stated that "Dr. MONTAGNE

had the opportunity of inspecting three sets [of CUMING's plants] in the Paris Herbaria, but did not always find the same numbers attached to the same plant in these collections". This fact would account for the want of uniformity in the numbers under which this species is quoted. In the herbaria of the British Museum and of Kew it is under CUMING's number 2234, whereas according to MONTAGNE it is under 2233 in Coll. Delessert. But on the same page (l. c. p. 659) MONTAGNE cites *Halimeda macroloba* as n° 2233 in Coll. Berkeley; and this corresponds precisely with the number attached to *H. macroloba* in the herbaria of both the British Museum and Kew.

In 1878 *A. erecta* was described for the third time under a new name, *Chloroplegma papuanum* (l. c.) by ZANARDINI, from specimens collected by BECCARI at Sorong, New Guinea (figs. 86, 87). ZANARDINI was aware of the publication of *Udotea sordida* Mont., because twenty years earlier he had speculated as to its identity with his own *Chloroplegma sordidum* of the Red Sea, which we show under *A. amadelpha* to be a synonym of that species. ZANARDINI's description of *Chloroplegma papuanum* is one of a series of preliminary diagnoses which the author intended, as he tells us (l. c. p. 34, footnote), to amplify with details and illustrations in a later paper. This intention was however frustrated by his death in the same year.

The list of synonomy shows three more names under which *A. erecta* has been described and published. It was not till 1889 that Messrs. MURRAY and BOODLE placed it in the genus *Avrainvillea* under ZANARDINI's specific name *papuana*, which title was adopted by DE TONI in his Syll. Alg. (l. c. p. 514). The plants figured by Messrs. MURRAY and BOODLE (l. c. tab. 289), were probably furnished by FERGUSON under n° 290 of his Ceylon Algae. They certainly do not represent ZANARDINI's type of *Chloroplegma papuanum* (if we may judge from the co-type).

Such is the history of the species under its various names. According to the International Rules of Botanical Nomenclature of the Vienna Congress (1905), it is necessary to drop the specific name *papuana* in favour of the earliest published name, which is found in *Dichonema erectum*. There is however a remote possibility that the specific name *erecta*, dating from 1842, may have to give way to *obscura*, should *Anadyomene obscura* Ag. (1823) prove to be identical with the present species. This question is discussed on p. 33.

A. erecta is by no means a rare alga in the Eastern Indian Ocean, ranging from the Madras coast to New Guinea; and its characteristic simple form and yellow filaments allow it to be recognised without much difficulty. The absence of torulosity is a constant character in the frond filaments and their colour is always of a more or less intense yellow, often deepening to an orange-brown in younger filaments. The size of the filaments is however liable to variation in the same plant, and even in one and the same filament, being smaller inside the frond and a good deal wider where they project outside the felt-work of the frond, especially round the margin of the flabellum. (For variation in size see figs. 85, 87, 88.)

It is interesting to note that two specimens in the British Museum, one certainly and the other probably collected in the Gulf of Manaar [Pearl Bank, Ceylon (HERDMAN) and Coast of Madras (THURSTON)] have the frond-filaments more slender than is usual in most specimens, ranging from about 27 μ to 42 μ.

Until the year 1907, the fructification of *Avrainvillea* had never been observed, but

in October of that year Dr M. A. Howe described (Bull. Torrey Bot. Club XXXIV. 1907 p. 504 tab. 28) the sporangia of *A. nigricans* Deene., which he had discovered on plants collected by himself at Montego Bay, Jamaica. Since then we also have found sporangia in that species (see p. 20), as well as on the spirit specimen of *A. erecta*, collected by Mr. THURSTON on the coast of Madras and preserved in the British Museum (fig. 89). These sporangia correspond with the description and figures given by Dr. HOWE (l. c.). They are borne on short filaments, emerging all over the surface of the frond, but they are all empty. There is unfortunately no record of the date or season when Mr. THURSTON's specimen was gathered.

Chlorodictyon pachyfus of KJELLMAN (WITTROCK et NORDSTEDT Alg. exsicc. n° 343) appears to us to consist of pollarded specimens of *A. erecta*, the fronds of which have been eaten away by turtles or other animals and are in course of regeneration. Compare note on Prof. OLTMANNS' plant (p. 10).

A. erecta has a distribution reaching from Madras to New Guinea.

5. *Avrainvillea obscura* J. Ag.

Syn. *Anadyomene obscura* Ag. Sp. Alg. (1823) p. 401.
Avrainvillea obscura J. Ag. Till. Alg. Syst. V. (1887) p. 53; Murray et Boodle in Journ. of Bot. XXVII. 1889. p. 71; De Toni Syll. Alg. I. 1889. p. 515.

Hab. PACIFIC. Guham, Marianne Islands, *Gaudichaud.*

C. A. AGARDH's original description is as follows: — "? *Anadyomene obscura*, fronde "cuneata, venis obsoletis. In mari Australi, ad insulam Guham. Specimina dedit Gaudichaud. "Radix subbulbosa. Frons ex angustiori basi (quasi stipitata) dilatata, cuneata, longitudine "digitalis, unciam lata, sublobata. Venae implicatae, sparsae, obsoletae, rubrae. Color "viridescens, luridus. Substantia stipitis firmior, crassior, partis superioris membranacea. "An Zoophyton?"

J. G. AGARDH (loc. cit.) gives the following description: — "*Avr. obscura* fronde supra "imam basem dilatatam surgente stipite brevi complanato, apice in flabellum terminale latius "cuneatum crassum luridum, margine erosum abeunte". And he explains that the "venae" of the elder AGARDH are darker brown filaments among the green [Figs. 90, 91].

The type of this species was collected by GAUDICHAUD at Guham in the Ladrone or Marianne Islands in the Pacific Ocean, and is preserved in the Agardh Herbarium at Lund University. We have been unable to examine even a fragment of this plant owing to the stringency of the regulation which forbids the loan of any specimen from the Agardh Herbarium. But we are greatly indebted to Prof. OTTO NORDSTEDT for his kindness in making and sending to us a number of sketches of some filaments of the plant as well as some outline sketches of the specimens which constitute the type (fig. 90). The filaments he kindly drew to scale with camera lucida, thereby affording us a fair notion of the main details that characterize the structure of the plant (fig. 91). The average diameter of the ultimate ramuli of the frond filaments appears to be about 30 μ, and that of their clavate apices reaches 50 μ. Lower down, the filaments usually measure 40—60 μ, but occasionally reach a diameter

of 80 μ. The filaments are cylindrical. So far as we can tell, *A. obscura* appears to be allied to *A. erecta* in structure; and for geographical reasons this might well be expected since its place of origin is situated to the north of the distribution-area of *A. erecta*. From this latter species it differs in habit, being stipitate and widely cuneate, whereas *A. erecta* is nearly always subsessile and reniform or securiform; the frond filaments of *A. obscura* are usually more clavate at their apices, and apparently not of the orange colour characteristic of *A. erecta*. Should GAUDICHAUD's plants prove to be conspecific with *A. erecta*, then the latter name dating from 1842 would have to give way to *A. obscura* which harks back to 1823.

The type locality quoted by C. A. AGARDH (l. c.) is "In mari Australi, ad insulam Guham", which J. G. AGARDH (Till Alg. l. c.) renders "Hab. in Oceano pacifico calidiore; ad Guham in insulis Moluccis a Gaudichaud lecta". We would point out that GAUDICHAUD himself spells the name of the Island "Guam" and describes it as one of the Marianne Islands in FREYCINET's Voyage Autour du Monde IV. Botanique (1826) p. 64. Hence J. G. AGARDH was wrong in supposing Guam to be in the Moluccas.

The sketches reproduced here are some of the above-mentioned drawings sent to us by Prof. NORDSTEDT.

6. *Avrainvillea clavatiramea* n. sp.

Hab. INDIC. Victoria: Port Phillip, Corio Bay (10. 2. 87)! and Port Phillip Heads (9. 1. 88)! coll. *J. Bracebridge Wilson.* Both in Herb. Mus. Brit.

Plant green to brown, up to 14 cm. high, solitary; stipes up to 3.5 cm. long, arising from a small bulbous base, expanding cuneately into the frond; frond flabellate, rotundate or proliferous at apex, up to 7.5 cm. long by 8 cm. broad, thick below, membranaceous at upper margin, green, often zonate.

Frond-filaments yellowish-brown, of rather large size, usually 35—55 μ in diam., rather straight, often torulose towards the apices, apices subclavate and obtuse. [Figs. 92, 93].

The specimens from which this description was drawn are in the British Museum (fig. 92) and bear a label with the following note: "*Avrainvillea* anne *A. obscura* prox.? J. AGARDH". Although as explained under *A. obscura*, we have been unable to obtain any material of that species for examination, we have several camera lucida sketches supplied by Prof. NORDSTEDT, which show that the frond filaments of *A. obscura* are more variable in diameter (30—80 μ) than in *A. clavatiramea*, and though clavate they are not torulose at the apices. (Compare fig. 91 with fig. 93). These differences, coupled with the fact that the original localities of the two species are so widely separated from one another and are quite unconnected by any ocean currents, convince us that the two species are distinct, though similar in external habit.

7. *A. Ridleyi* n. sp.

Syn. *A. lacerata* A. & E. S. Gepp in Journal of Botany XLIII. 1905. p. 339.

Hab. INDIC. Christmas Island, Flying Fish Cove, n° 224! — and Waterfall Cove, n° 243 pro parte! Coll. *H. N. Ridley.* Oct. 1904. — Flying Fish Cove, *C. W. Andrews,* n° 249! (spirit specimen) .... All the specimens in Herb. Mus. Brit.

Plant brown, about 5 cm high, tufted, arising from a harder common base, very irregularly branched; lobes 2.5—4.5 cm long, spongy, congregated, often concrescent, usually stipitate below, above cuneately thickened, fasciculate, difform, here and there divided (flabella absent or eroded). Filaments of the frond of medial thickness, 25—35 μ diam., usually torulose, sometimes more or less mingled with cylindric filaments, with pale brown contents, here and there dense brown; ultimate ramuli sometimes subclavate. [Figs. 94—96].

This species, originally gathered by Mr. Ridley in October 1904, and later by Mr. C. W. Andrews in 1908 upon the surf-beaten coast of Christmas Island, situated about 200 miles to the south of Java, much resembles in external habit clumps of *Ectocarpus spongiosus* when dry (Fig. 94 is a spirit-specimen). They were erroneously referred by us (loc. cit.) to *A. lacerata* J. Ag. But we now find them to be quite distinct from that species in the size and character of their frond-filaments. In *A. lacerata* the frond-filaments are smaller and taper from a diameter of 25 μ, where thickest, down to 5 μ at the apices, which are usually colourless. The Christmas Island plants are quite different in habit and their filaments are usually torulose, and are thicker and more uniform in size (25—35 μ), with brown, stout, sometimes sub-clavate apices (figs. 95, 96). The peculiar tufted habit of the Christmas Island plants recalls that of the reef form of *A. amadelpha*, and, as in that form, is doubtless due to exposure to the rough surf which beats upon the shores of the island.

The nearest ally of *A. Ridleyi* is *A. clavatiramea*, from which it differs entirely in habit, and the somewhat smaller size of the usually torulose filaments which are less conspicuously clavate.

8. *Avrainvillea canariensis* n. sp.

Syn. *Udotea tomentosa* Vickers in Ann. Sci. Nat. 8e sér. tom. IV. 1896. p. 300.

Hab. Atlantic. Gran Canaria, Las Palmas, *A. Vickers* in Herb. Madame Weber! & in Herb. Bornet!

Plant brownish-green, about 12 cm. high, solitary, stipitate; stipes 5—6 cm. long, simple, compressed, expanding cuneately into the frond; frond rotundate, large, 6—9 cm. long by 7—11 cm. wide, very obscurely zonate, thin, margin subentire to fimbriate or slightly lacerate; frond-filaments cylindrical, here and there torulose, not tapering nor clavate, green to fulvous-brown, often collapsed and colourless when dry, coloured filaments usually 30—40 μ diam. [Figs. 97, 98].

The finding of this species was described by the late Mademoiselle Vickers (op. cit. p. 295) as follows: "Sur le chemin de Telde, à 3 kilomètres de Las Palmas, il y a quelques rochers qui ne sont pas trop mauvais. Je suis arriveé là un jour au moment où l'on tirait la senne. Toute la population des environs y était assemblée, hommes, femmes et enfants. Pour eux la pêche a été mediocre; moi, j'ai eu la chance de prendre possession de six beaux exemplaires d'*Udotea (Rhipilia) tomentosa*, ramenés par ces filets et laissés sur le sable par les pêcheurs".

We have seen two of her specimens (one is shown in fig. 97) and are unable to refer them to any known species, nor can we regard them as near allies of any other species.

Perhaps they come near to *A. Elliottii*, but that species has a thicker smaller sublobate frond often eroded above, and its filaments are smaller; but it has an erect rhizome, as also *A. canariensis* appears to have, though we have ignored the transition from rhizome to stipes in our description, and have regarded the whole as a stipes merely, since it is almost impossible to distinguish the point of junction in specimens which have been so crushed in drying. The ultimate branchlets of the frond-filaments may be either cylindric or torulose (fig. 98); or the filaments may be torulose further behind the apex. They are not easy to tease out for examination under the microscope being somewhat intricately interwoven and adherent. A very large proportion of them are collapsed and colourless, possibly owing to their having been collected in midwinter.

This is the only species of *Avrainvillea* which we have ever seen from near the West coast of Africa.

9. *Avrainvillea Elliottii* sp. nov.

Syn. *Avrainvillea sordida* Murray & Boodle in Journ. of Bot. XXVII. 1889. p. 70 (quoad specimen "Grenada, Murray".)
Avrainvillea sordida Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Avrainvillea sordida De Toni Syll. Alg. I. 1889. p. 514 (pro parte).

Hab. ATLANTIC. Grenada, Morne Rouge Bay. *Elliot.* May, June, 1887 (Brit. Mus. spirit collection n^0 218)!

Plant (spirit specimens) brown, 6—13 cm. high, apparently solitary. Rhizome erect, about 5 cm. high, 1 cm. thick, sometimes with 1 or 2 lateral swellings or thickenings (scars of other stalked fronds), continued into the stipes.

Stipes 1—4 cm. long, 0.6—1 cm. thick, slightly compressed, simple, expanding suddenly into the frond.

Frond from a usually truncate base, widely flabelliform in young plants but irregular in older plants, short (3.5—5 cm.), wide (5—10 cm.), eroded above, lobed, sometimes split almost to base, of medium thickness, zonate, surface minutely wrinkled, the lobes sometimes divaricate and prolonging their growth.

Frond-filaments cylindrical, sometimes slightly torulose, often brownish-yellow, rather small, usually 20—30 μ thick, rarely 15 μ at young apices, not specially ramified or tapering at apex. [Figs. 99, 100].

The specimens upon which this species is founded (fig. 99) are preserved in a bottle labelled in Mr. MURRAY's handwriting "*Avr. sordida* Crn. (excl. syn.)", and being the only Grenada specimens so named are obviously those cited by MURRAY and BOODLE (loc. cit.) under *A. sordida* as "Grenada, Murray". Mr. W. R. ELLIOTT collected marine algae for Mr. MURRAY after the visit of the latter to Grenada in 1886.

The shape of the frond of *A. Elliottii* is very irregular. When young it has a short rotundate base and spreads flabellately above with entire margin. After they have attained a width of 5 cm. they begin to grow out into two or more broad main lobes, generally situated

towards the side, the middle of the upper margin of the frond being often eroded or becoming more or less deeply cleft. They are distinctly zonate. The frond-filaments (fig. 100) are often filled with dense brownish yellow contents, but again often are pallid and contain granules (starch etc.). A common feature at the base of dichotomial branches is the presence of a slight swelling, densely coloured or pallid, immediately above the basal constriction.

The plants in question differ from *A. sordida* in structure, that is in being composed of filaments having a fairly uniform size, slightly larger than that of the thickest filaments of *A. sordida*. They are usually more deeply coloured, more uniformly cylindrical and do not taper down to slender terminal ramuli (6 μ in diameter). They exhibit some points of resemblance with KÜTZING's figure of his *Rhipilia longicaulis* (Tab. Phyc. VIII. 1858. p. 13, tab. 28, fig. II.), to wit, the upright rhizome with one or more thickenings or scars of fallen fronds, as well as the split frond, though in *A. Elliottii* the frond is not obovate but semiorbicular, and twice as wide as KÜTZING's frond. But as regards the filaments, if the accuracy of KÜTZING's drawing and magnifications can be depended upon, the filaments of *R. longicaulis* Kütz. taper from about 25 μ at the coloured torulose part down to 5 μ at their colourless apices. In *A. Elliottii* on the other hand, the filaments scarcely taper at all, being rarely less than 20 μ at the apices and measuring 25—30 μ elsewhere. Further remarks about *Rhipilia longicaulis* Kütz. are given under *A. Mazei* and *A. sordida*.

10. *Avrainvillea Gardineri* A. & E. S. Gepp

in Trans. Linn. Soc. (Bot.) VII 1908 p. 179; pl. 24, figs. 23, 24; (Zool.) XII. 1909 p. 389, pl. 49, figs. 23, 24.

Hab. INDIC. Cargados Carajos, 22—47 fathoms, *J. Stanley Gardiner*!

Plant large, attaining a height of over 30 cm., solitary, consisting of a stout lurid-brownish rhizome, 9—12 cm. long, 1.5 cm. thick, ascending somewhat obliquely from a bulbous base, and suddenly transformed at its apex into a short flattened green stipes, 1.5—2.5 cm. long, 6—9 mm. wide, which bears the frond. Frond very large, dark olive to lighter green, not brown, up to 18 cm. long, 20 cm. wide, rotundate, at base usually cordate or auriculate-cordate, membranaceous, zoned, margin entire in young plants, coarsely lacerate in large plants. Filaments of frond laxly interwoven and easily teased apart, 20—30 μ in width, not tapering to apices, for the most part regularly torulose; apices slightly tortuous, free, not interwoven [Figs. 101, 102].

This species was recently obtained from deep water in the western part of the Indian Ocean by Mr. GARDINER during the "Sealark" Expedition. It attains large dimensions (fig. 101 is half natural size) comparable with those recorded for the West Indian species, *A. nigricans* Decne. It is remarkable for its long sub-erect rhizome, which gives the plant the appearance of having a long stalk; but the actual stipes which bears the frond rarely reaches a length of 2.5 cm. This stipes is terminal, i. e. continuous with the rhizome, but distinguished from it by change of colour, smaller diameter and flatter shape. The impression one gets from the plant is that the rhizome grows immersed in mud and the stipes and frond stand out in the clear water above. The frond is thin and when held up to the light reveals the zonate markings

very clearly. When young and small it is quite entire, but in old plants it is often deeply and flabellately lacerate. In colour the frond varies from a deep olive to a lighter green, while the rhizome is pale brown. The shape of the frond is rather cuneate in young plants and in older ones it is often auriculate-cordate.

The filaments of the frond are markedly torulose (fig. 102) for some distance behind the apex and do not taper towards their apices. These are often tortuous but not markedly interwoven.

The nearest ally of *A. Gardineri* in structure is *A. pacifica* (infra), which it resembles in the torulose character of the filaments and to a certain extent in their diameter; but the habit of the two species is quite different, as also their geographical distribution. *A. Gardineri* bears one thin large solitary frond, arising from a long rhizome, while *A. pacifica* bears two or even more comparatively small fronds arising from a short thick base. The filaments of *A. pacifica* vary in diameter to a greater extent (25—6 μ) than those of *A. Gardineri* (30—20 μ).

A. Gardineri resembles *A. nigricans* Decne. in having torulose filaments, but differs greatly in the diameter of the filaments, those of *A. nigricans* measuring 60 μ or more inside the frond, diminishing to 30 μ at their apices. Moreover *A. nigricans* is a West Indian species, while *A. Gardineri* is as yet known only from Cargados Carajos in the western Indian Ocean. This region is also the home of *A. amadelpha*, which however has a wider local distribution, and differs from *A. Gardineri* in habit and structure. *A. amadelpha* consists of from two to many fronds arising from a common base, and is characterised by smaller and tapering frond filaments, which usually form a pseudo-cortex upon the surface of the frond.

11. *Avrainvillea pacifica* n. sp.

Hab. PACIFIC. Ellice Isles: Fualopa, A.14. *David*! Funafuti Expedition, 1898. — Paumotu Archipelago: Otépa récif, 1904, *L. G. Seurat*! — Hikueru lagon, 1905, *L. G. Seurat*!

Plant brownish, consisting of 2 or more stipitate fronds arising from a thickened base; stipes short (up to 2.5 cm. long), stout (up to 1.25 cm. thick), bearing a cordato-semirotundate frond, ezonate, margin entire, rather thick (not membranaceous). Frond 5.6 cm. long, 8.1 cm. wide (in type). Filaments of frond thin, tapering in interior from 25 μ down to about 6 μ at their apices, wide-angled at their dichotomies, longly and markedly torulose, colourless to light-brown, apices often tortuous or hooked, not interwoven into a pseudo-cortex, but easily teased asunder. [Figs. 103, 104].

The details of the above description were drawn from the Fualopa specimen (fig. 103) which is preserved in alcohol in the British Museum. The other specimens, kindly sent to us by Monsieur P. HARIOT in April 1907, and referred by us at that time to *A. lacerata*, are dried plants. One of them has four crowded fronds arising from the common base. All of them have a thinner frond and more slender stem; and the outline of the frond varies from cuneato-flabellate to rotundate. The structure however is that of *A. pacifica*.

A. pacifica belongs to the group of species which cluster round *A. lacerata*, being allied with *A. amadelpha*, *A. sordida* Murr. & Bood. and *A. asarifolia* Börg. It resembles

them in the size of its filaments and in their manner of tapering to the apices which in some of the species are often tortuous. It differs from all of them in having its filaments more uniformly and more strongly torulose (fig. 104); and from *A. amadelpha* it differs in having no trace of pseudo-cortex.

12. *Acrocystis lacerata* J. G. Agardh.

Syn. *Ulva lacerata* Harv. Exsicc. Friendly Islands n° 86.
Acrocystis lacerata J. Ag. Till Alg. Syst. V. (1887) p. 54; Murray et Boodle in Journ. of Bot. XXVII. 1889. p. 71 (pro parte); De Toni Syll. Alg. I. 1889. p. 515 (pro parte).

forma *typica*:

Hab. Pacific. Friendly Islands 1855, *Harvey* n° 86 in Herb. Mus. Brit.! and Herb. Kew! — Vavau, *Harvey* in Herb. Mus. Brit.!

Indic. *Siboga Expedition.* Stat. 129. Karkaralong Islands, reef! — Stat. 131. Beo, Karakelang Islands, reef! — Stat. 213. Saleyer reef! — Stat. 299. Buka Bay, Rotti, reef! — Stat. 312. Saleh Bay, Sumbawa, 15—30 m.

var. *robustior*:

Hab. Singapore, Bapon, 5. 2. 94. *Ridley*! — Singapore, Foas, Feb. 1890, *Ridley* n° 103, in Herb. Mus. Brit!

Plant green to greenish-brown, up to 10 cm. high, either bearing fronds on branches issuing in a tuft from a rhizome, or forming a more or less compact clump of shortly stalked fronds.

Rhizome abbreviated, bearing slender dichotomously divided branches up to 1—2 cm. long, or passing at once into the short stalks of the fronds. Frond varying from cuneate-obovate and lacerate, to cordate-subrotundate and almost entire, always thin, sometimes zonate, varying in size up to 5 cm. long by 6 cm. wide, but commonly about 2 cm. either way.

Filaments of frond mostly 25 μ in diam. and tapering to about 6 μ at the colourless apices, which are frequently irregularly torulose and tortuous for a short distance behind their apices; filaments of the interior cylindrical, straighter and often yellowish-brown in colour. Supra-dichotomial constrictions distinctly long-necked. [Figs. 105—109].

forma *typica*.

Fronds borne on dichotomous branches up to 2 cm. long, cuneate, commonly obovate and lacerate, sometimes zonate. (NB. The plants figured — figs. 105, 106 — are dried specimens.)

var. *robustior*, var. nov. (? spec. propr. *Acrocystis robustior*).

Rhizome abbreviated, thick, bearing a few branches from which arise the more or less crowded fronds on short stalks 3—10 mm. long. Fronds cuneate-oblong to cordate-rotundate, sometimes overlapping one another, rather thin, zonate, entire or fringed. Frond-filaments with long-necked supra-dichotomial constrictions. The whole plant stouter and more luxuriant than

f. *typica*. Supra-dichotomial constrictions more long-necked than in f. *typica* (compare figs. 106*a* and 109*a*). (NB. The plant figured — fig. 108 — is not a dried plant, but a spirit specimen).

Udotea lacerata was founded by HARVEY on specimens collected by him in the Friendly Islands and issued without description in his Alg. Exsicc. Friendly Islands under n° 86 (fig. 105). The first diagnosis was published in Till Alg. Syst. V. (1887) p. 54 by J. G. AGARDH, who rightly places the species in *Avrainvillea*. He points out a similarity in habit to *Udotea Desfontainii* and discusses the possibility of its identity with *Udotea sordida* Mont. (Philippines, CUMING) a point which, for want of material of the latter plant, he was unable to decide. He also debates its possible affinities.

The typical form of *A. lacerata* is a well-marked plant, varying but slightly in habit. It is characterised by the production of many small, thin fronds borne on slender stalks arising from a repeatedly branched stem. The Siboga specimen (fig. 107) agrees nearly with the type (fig. 105). It is constant also in the characters of the frond-filaments (fig. 106) which are similar to those of *A. sordida*, both in size and form. They are also in size much like the filaments of *A. amadelpha*, being about 25 μ wide, and cylindrical not torulose in the older parts of the filament, while towards the apices they diminish to 6 μ in width and often become irregularly subtorulose for a short distance below the apices. The apices are not however unilaterally torulose and tortuous as in *A. amadelpha*; nor do they, as in that species, intertwine so as to form a pseudo-cortex. Even in reef-forms *A. lacerata* is a much more slender plant than *A. amadelpha*; and in deep water *A. lacerata* differs but little from its reef-form, whereas *A. amadelpha* in deep water grows to three times the size of its reef-form. *A. lacerata* differs from *A. pacifica* in structure, the filaments of the latter being very torulose and not cylindrical.

From *A. sordida*, *A. lacerata* differs in habit and in geographical distribution. *A. sordida* has a stem which is either simple or once dichotomous, thus bearing one or rarely two rounded fronds with cordate base, whereas in *A. lacerata* the stem is usually divided into several slender long or short branches, each bearing a frond which is small, membranaceous and fimbriate: also *A. sordida* is limited to the West Indies where it is a well-known plant. In the characters of the frond-filaments alone it is difficult to find a satisfactory distinguishing feature between the two species.

var. *robustior*.

In the British Museum are several specimens collected by Mr. H. N. RIDLEY at Singapore (fig. 108 is a spirit-specimen), which correspond exactly with *A. lacerata* in structure, though diverging in habit. They are stouter and browner, and have larger and shorter-stalked fronds which are more crowded and more overlapping than in the typical *A. lacerata*. We do not know whether they came from deep water or shallow. In habit they approach the surf-form of *A. amadelpha*, but differ in structure, the tapering apices of the frond-filaments being less tortuous, enodulose, not hooked and felted together into a pseudo-cortical layer as in *A. amadelpha*. Var. *robustior* occurs in the western limits of the distribution-area of *A. lacerata* and well outside the area of *A. amadelpha*.

13. *Ivrainvillea sordida* Murray & Boodle

in Journ. of Botany XXVII. 1889. p. 70 (pro parte).

[Not *Udotea sordida* Mont. in Hook. Lond. Journ. of Bot. III. 1844. p. 459.]

Syn. *Halimeda tuna* var. Kütz. Tab. Phyc. VIII. 1858. p. 13, tab. 28, II.

Avrainvillea sordida Crouan ex Maze et Schramm Algues de la Guadeloupe, 2me Edit. 1870—77. p. 80 (pro parte).

Avrainvillea sordida Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).

Avrainvillea sordida De Toni Syll. Alg. I. 1889. p. 514.

Avrainvillea levis Howe in Bull. Torrey Bot. Club. XXXII. 1905. p. 565, tab. XXIII, fig. 1, tab. XXVI, figs. 8—10.

Avrainvillea levis Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 390.

Avrainvillea spec. Borgesen in Vid. Medd. nat. Foren. Kjobnhavn. 1908 p. 36, figs. 5, 6.

Hab. Atlantic. Guadeloupe, Basse Terre, sur la coquille du *Strombus gigas Mazé* n° 30 1ère série in Herb. Mus. Brit.! n° 30 in Herb. Kew! Bahamas, Cave Cays, Exuma Chain, *Howe* n° 3000! — Bahamas, Cockburn Harbor, South Caicos, *Howe* in Phyc. Bor. Amer. n° 1478! — Jamaica, fide *Howe*. — ? St. Jan, Maho Bay, at a depth of 16 met., *Börgesen*.

"Olivaceous when living, on drying often slightly tinged with yellow or verging toward "cinerous, or at the margins sometimes fuscous, caespitose or gregarious from a short scarcely "rhizomatous base; stipe 0.5—4 cm. long, flattened or subcylindrical, simple or occasionally "dichotomous at base: flabellum varying from reniform-suborbicular with cordate base to "cuneiform-obovate, 1—7 cm. broad, entire, erose, or sometimes lobed, thin and membranous "or sometimes thicker and coriaceous, compact in texture with a smooth or slightly wrinkled "surface, for the most part distinctly zonate, now and then tending to form serially superposed "flabella at the margins of the zones: filaments of flabellum slender, tortuous, interwoven, "usually lightly and irregularly torulose, rarely somewhat moniliform, mostly 6—24 μ in diam.; "those of interior a little larger (reaching 35 μ), more chlorophyllose and less tortuous: angle "of dichotomy commonly acute (about 30°—45°), sometimes obtuse (reaching 120°)". — M. A. Howe in Bull. Torrey Bot. Club XXXII (1905) pp. 565, 566 [Figs. 110, 111].

In accordance with the Vienna rules of nomenclature, we retain for this species the oldest specific name, to which no doubt can be attached. Though no description was published by Maze and Schramm with Crouan's binomial, a diagnosis was supplied by Murray and Boodle (loc. cit.). They included in their *A. sordida* some plants which belong to other species; but their type-specimen (fig. 110), Mazé n° 30, stands good, and is preserved in the British Museum. They rightly reject *Udotea sordida* Mont. from the synonomy of this species. Montagne's plant was collected in the Philippine islands by Cuming and is a synonym of *Avrainvillea erecta*. Mr. Howe's recent and careful description of the present species under the name of *A. levis* is so good that we have taken the liberty of quoting it in full.

Mr Howe speaks of "the filaments of the surface being often more slender, more "tortuous, and less chlorophyllose than those of the interior". In some plants of Maze's n° 30 which we have examined, these very slender (6—10 μ diam.) peripheral filaments are locally rare or absent from some parts of the frond. We give in fig. 111 some typical filaments from the type-plant, showing the supra-dichotomial branches to be subtorulose and more coloured for a short distance above their base.

The nearest ally of this species is found in the Indian and Pacific Oceans. Though very different in habit from *A. lacerata* J. Ag., the type locality of which is the Friendly Islands where it was originally found by HARVEY, yet in structure *A. sordida* is almost identical with *A. lacerata*, that is to say in the size and character of its filaments. *A. asarifolia* of the Danish West Indies and *A. amadelpha* of the Indian Ocean differ from *A. sordida* in the peculiar tortuous, irregularly swollen, branched peripheral filaments felted into a pseudo-cortex. *A. pacifica* differs in having its filaments more extensively and uniformly torulose.

The "*Avrainvillea* spec." of Dr. BÖRGESEN (loc. cit.) we have once seen, but have not had the opportunity of submitting to a searching examination. Judging from Dr. BÖRGESEN's description and figures of the plant, we should suppose it to be a form of *A. sordida*, unless indeed it be a form of *A. asarifolia* Börg.

Avrainvillea sordida is quite remarkable for the extraordinary concatenation of errors, speculations and misunderstandings which mark its history. MAZÉ and SCHRAMM began the trouble by publishing CROUAN's MS. name *A. sordida* without a description, but founded on three cited specimens [1]), the second and third of which belong to *A. nigricans*, but the first stands good as type; they also cited three synonyms [2]) (species never seen by them nor by CROUAN), all of which are in reality distinct from *A. sordida* and from one another. In 1889 MURRAY and BOODLE published a description of "*Avr. sordida* Crn. excl. syn.", and cited three specimens [3]) (in Herb. Mus. Brit.) which represent three distinct species [4]) and of which the first stands good as their type and bears the same number as CROUAN's type — viz. Mazé n° 30. They rightly exclude CROUAN's synonymy. In 1905 Dr. HOWE, for reasons stated by him, re-introduced the species "under a new specific name (*A. levis*) attached to a new nomenclatorial type" (Howe n° 3996) — a type undoubtedly conspecific with that of MURRAY and BOODLE, and with that of CROUAN. We ourselves are advised that the binomial of MURRAY and BOODLE is valid; but we have a strong conviction that it will have to give way to *A. longicaulis* (*Rhipilia longicaulis* Kützing), as we will now proceed to show.

In the synonymy of this species we have included with a query *Rhipilia longicaulis* Kütz. for reasons fully explained under *A. Mazei*. Briefly stated these reasons are as follows. Assuming that KÜTZING's description (loc. cit.) and figure are correct and that the degree of magnification of the enlarged filament is accurately stated, we find that the dimensions and character of the frond-filaments of his *R. longicaulis* correspond with those of *A. sordida* and of no other West Indian species known to us. We have had no opportunity of examining KÜTZING's type; but KÜTZING was a draughtsman of wide experience, and his plates are as a rule accurate. If our inference should prove to be correct, the binomial *A. longicaulis* would have to be reserved for the present species, since the name *longicaulis* takes precedence even of CROUAN's *sordida* by several years. And thus the unhappy combination *A. longicaulis* employed by MURRAY and BOODLE in 1889 to denote plants which are identical with *A. nigricans*, and

1) N^os^ 30, 174, 174 bis.
2) *Udotea sordida* Mont. (= *A. erecta*): *Chloroplegma sordidum* Zanard. (= *A. amadelpha*); *Rhipilia tomentosa* Kütz.
3) MAZÉ N^os^ 30 and 174 bis, and Grenada, MURRAY.
4) *A. sordida*; *A. nigricans*; *A. Elliottii*.

recently employed by Mr Howe (1907) to include *A. Mazei*, would now have to be transferred to the third and last of the older West Indian species — *A. sordida* Crouan

14. *Acrosiphonia arcta* Gepp

in Trans. Linn. Soc. (Bot.) VII. 1908. p. 178. pl. 23. fig. 20; pl. 24, figs. 21, 22; (Zool.) XII. 1908. p. 388. pl. 48. fig. 20, pl. 49. figs. 21, 22.
Ulva arcta Mont. in Ann. Sci. Nat. VII. 1857. p. 136.
Chlorophyllum sordidum Zanard. Plant. in Marc Rubro Enum. in Mem. Ist. Venet. VII. 1858. p. 262. tab. XIII. fig. 1.
Ulva arctissima De Toni Syll. Alg. I. 1889. p. 509.
Acrosiphonia lacerata Hieron. in Engler Pflanzenwelt Ostafrikas. Theil C. p. 24. 1895.
Acrosiphonia lacerata Harvey-Gibson in Journ. Linn. Soc. (Zool.) XXXI. 1908. p. 77.

Hab. Indic. Galega, *Le Duc* in Herb. Mus. Paris! and Herb. Kutzing! — Mauritius, *Pike*! — Amirante, 30 fathoms; Coetivy reefs exposed at dead low tide; Saya de Malha, 25 & 29 fathoms; Cargados Carajos, 47 fathoms; Salomon (Chagos Archipelago) reefs exposed at dead low tide, *J. Stanley Gardiner*! — Red Sea, Suez, Tor, *Portier*. — Suez, *Crossland*.

Plant green or brown, either consisting of numerous small congregated fronds arising from a more or less thickened base (reef form); or of fewer and larger fronds borne upon longer stalks (deep water form). Stalks rather thick, 1—3 times dichotomously branched, 2—6 cm. high, bearing fronds which vary from 1—7.5 or even 10 cm. high, by 1—5.5 cm. wide.

Fronds from a cuneate or shortly elliptic base, sub-rhomboid rotundate, zonate, rather thin, in reef forms very much reduced by erosion.

Filaments of frond slender, interwoven, cylindrical, towards the apices torulose, tortuous, branched; branches curved, irregularly swollen, often unilaterally torulose and felted together so as to form a pseudo-cortex of the flabellum, varying from 25 μ inside the flabellum to about 15 μ at the apices of the filaments, and occasionally to 6 μ. [Figs. 112, 115].

forma *Montagneana*.
Plants short (6 cm.), densely congregated, fronds very much eroded, obsoletely zonate.

forma *submersa*.
Plants tall (up to 18 cm.), fronds few, large, entire, zonate.

The first record of this species is Montagne's description, under the name of *Udotea arctissima*, of the specimen (fig. 112) collected by Le Duc at Galega in the Indian Ocean, published in 1857. The specimen in question is preserved in the Herbarium of the Paris Museum, a portion of it came into the possession of Kützing, and is in his herbarium, now the property of Madame Weber van Bosse. This fragment bears a label in Montagne's handwriting, declaring its authenticity. Both these portions of the original plant we have been allowed to see by the kindness of their respective custodians. The habit of Montagne's original specimen may be described as follows. From a thickened crowded base spring many short thickish stalks, most of which branch dichotomously and bear small rather thin fronds of irregular shape. The whole plant is of a brownish colour and about 6 cm. high. The basal part has a more or less felt-like hairy appearance, caused by the projection (beyond the surface) of

the ends of component filaments. Montagne published no figure and though his description is quite a good one, and has been copied by De Toni in Syll. Alg. I. p. 509, the plant has never been recognised since.

In the following year, 1858, was published Zanardini's account of algae collected in the Red Sea (l. c.). This paper had been read before the Istituto di Scienzia at Venice in 1857, but as the actual publication apparently did not take place till 1858, it is obvious that Montagne takes precedence of Zanardini. Zanardini describes among his Red Sea algae a new genus *Chloroplegma* for the reception of a species which he calls *C. sordidum*. We have not been able to examine his specimens, but from the description and figures and locality we have no hesitation in identifying it with Montagne's *Udotea amadelpha*. The likeness in habit between his fig. 1 *a* and the type of *U. amadelpha* is obvious, while the plant represented in fig. 1. with its larger and more regular fronds, probably represents a form from deeper water, such as we have found (fig. 114) in Mr. J. Stanley Gardiner's collection from the islands of the western Indian Ocean and described in Trans. Linn. Soc. (Bot.) VII. 1908, p. 178.

Till recent times it has been unusual to find records of the depth from which any marine alga has been collected and of the conditions under which it was growing; and this omission has no doubt prevented the recognition of what are mere growth-forms, or at least, has led to a misconception of the limits of certain species. Now that deep-water forms are more generally obtained by dredging, the importance of taking into consideration the vertical distribution is obvious. Mr. Gardiner's specimens of *A. amadelpha* gathered on the reefs, in the western Indian Ocean, exposed at dead low tide are about 5 or 6 cm. high and shew the congested habit of Le Duc's plant from Galega, as well as that of Zanardini's figure quoted above. The deep water plants on the other hand dredged from depths ranging from 25 to 27 fathoms, attain a height of 17 or 18 cm., the stalks alone being as long as the entire reef-grown plant. The fronds are large, not torn, and show the zonate marking clearly. The structural characters are identical in both forms (figs. 113, 115). A deep water example has been figured in our account of Mr. Gardiner's Algae (l. c.). The specimens collected by Col. Pike at Mauritius, preserved in the British Museum Herbarium, are clearly reef-forms, being small and congested, though not at all eroded. Possibly they grew in quiet water.

A. amadelpha is distinguished from other allied species by the peculiar twisted, torulose, curved and often unilaterally and interruptedly swollen apices of the frond-filaments (figs. 113, 115), which are often so interwoven as to form a thin pseudo-cortex of the frond. This character is very marked in Montagne's type and also in some of Mr. Gardiner's specimens, but in others of his collection and in Col. Pike's Mauritius plants this pseudo-cortex is not so well developed. However the ends of the frond-filaments are sufficiently curled and twisted in all the specimens to shew their identity. We have not so far been able to connect the development of this pseudo-cortex with any special conditions of the plant, such as depth of habitat.

A. amadelpha belongs to the "Formenkreis" of *A. lacerata*. In structure it is most closely allied to the West Indian *A. asarifolia*, but differs from it in habit. For in *A. amadelpha* the stipes is always branched and bears a few or many fronds according to whether the plant is much or little submersed; and the fronds are subrhomboid-rotundate with cuneate to rounded

base. In *A. asarifolia* on the other hand the stipes is not branched, the frond therefore is solitary, and its shape is oblong-reniform with cordate base.

The reef-specimens of *A. amadelpha* somewhat resemble in habit crowded compact plants of *A. lacerata*, and both species are characterised by having their principal filaments of the same size and of cylindrical, not torulose form. In both species these measure about 25 μ in the inside of the frond, the filaments of *A. lacerata* diminish in size to a diameter of 6 μ at their apices, whereas those of plants of *A. amadelpha* which possess a good pseudo-cortex usually measure about 15 μ at their apices. However in some plants of *A. amadelpha*, having a poorly developed pseudo-cortex, the filaments sometimes diminish to 6 μ at their apices. In such cases it is difficult to distinguish the two species, but for the fact that the ultimate branchlets of the frond filaments of *A. amadelpha* are usually torulose to a greater degree and along a greater length, are more tortuous and are often, so to speak, unilaterally torulose.

The geographical distribution is also a help. *A. amadelpha* is confined to the western Indian Ocean, a region from which we have as yet no authentic record of *A. lacerata*. It is true that ZANARDINI's *Chloroplegma sordidum* of the Red Sea has been commonly referred to *A. lacerata* by several authors; but that is because they did not realise the identity of *A. amadelpha*.

15 *Avrainvillea asarifolia* Börgesen

in Vid. Medd. Nat. For. Kjobnhavn 1908. p. 34, fig. 4, and tab. III.

Hab. ATLANTIC. West Indies: St. Thomas, off Water Island, depth 20 meters, *F. Borgesen.* — St. Jan, off Christiansfort, depth 30 meters, and near the isle of Gt. St. James, 30 meters, *F. Borgesen.*

Dark-olive-green or sometimes greyish when dried; most probably of a similar colour when living; rhizome terete; stipes cylindric in the lower part, more flattened higher up, 0—23 cm. long, about 7 mm. in diameter.

Flabellum oblong-reniform with cordate or cuneate base up to about 10 cm. high and 14 cm. broad, entire or lobed, thin and membranous, rather firm, for the most part zonate.

Filaments in the interior of the flabellum cylindric or often slightly moniliform or torulose with a rather strong constriction just above the dichotomy. The diameter of the filaments about 20—33 μ, more often reaching only 24—27 μ. Near the surface the filaments grow gradually slender, becoming more and more torulose and more richly ramified, woven together, forming a rather firm but yet open plectenchyma; the diameter of the outermost filaments varies from 8—11—13 μ, and their walls are rather thick, thicker than those of the filaments in the middle of the flabellum. Sometimes the apex of a filament runs out into a long hair. [Figs. 116, 117].

The above diagnosis is extracted with slight alteration from Dr. BORGESEN's account of the species. He compares it with *A. sordida* (*A. levis* Howe), as follows: —

"Compared with *Avr. levis* Howe, of which I possess an original specimen kindly sent to me by Dr Howe, my species differs, besides its largeness, by having the filaments of the surface much more torulose than in *Avr. levis* where the outermost filaments run out in long, thin, only very feebly torulose threads".

We have not examined *A. asarifolia*, but we recognise at once the similarity of structure in it (fig. 117) and in *A. amadelpha*, namely the tortuous, branched, irregularly swollen peripheral filaments felted into a pseudo-cortex of the frond. The two species are of course totally different in geographical distribution. In habit moreover they are quite distinct, *A. asarifolia* (fig. 116) being a simple plant with unbranched stipes, whereas *A. amadelpha* (figs. 114 and 112) has two or more fronds on a branched stipes, many stipites arising sometimes from the same compact rhizome. *A. asarifolia* bears the same relation to *A. amadelpha* of the Indian Ocean that *A. sordida* of the West Indies bears to *A. lacerata* of the Pacific and Indian Oceans.

3. Rhipiliopsis gen. nov.
(Figs. 118—122).

Thallus green, not encrusted with lime, shortly stipitate, excentrically subinfundibuliformly peltate to flabellato-rotundate, thin, rarely zonate, ecorticate, margin entire or lobed; filaments of frond cylindrical, thin-walled, very laxly interwoven, repeatedly dichotomously branched; branches much constricted at their base. Filaments often laterally attached here and there by a pseudo-conjugation of two short lateral prominences one from each of the two respective filaments, the two prominences often of unequal length; but the filaments remain persistently separated by a septum. In the older filaments these junctions break asunder, leaving a number of short conspicuous protuberances on the filaments.

1. *Rhipiliopsis peltata* nov. comb.

Syn. *Udotea peltata* J. Ag. Till Alg. Syst. V. 1887 p. 74.

Hab. Indic. Port Phillip Heads, Australia. *J. Bracebridge Wilson,* in Herb. Mus. Brit!

Plants green, up to 4.5 cm. long, consisting of stalk and frond; stipes short, 2—4 mm. long, up to 1 mm. thick; frond varying from excentrically peltate and somewhat infundibuliform to flabellately expanded, rotundate, measuring 2—4 cm. in width, varying from entire to lobate or sometimes lacerate, thin, rarely zonate, ecorticate.

Filaments of frond slender, 12—18 μ in diam., thin-walled, cylindrical, with occasional short prominences about 8 μ long, very laxly interwoven, repeatedly dichotomously branched, angle of dichotomy wide, branches narrowly and conspicuously constricted where they leave the dichotomy. Filaments immediately below a dichotomy often 23 μ in diam., young apical branchlets often subspherical, 22 μ in diam. [Figs. 118—112].

This species was described by J. G. Agardh (l. c.) from specimens collected by Mr. J. Bracebridge Wilson at Port Phillip Heads in 1892—3. Authentic specimens of these are now preserved in the British Museum (fig. 118), and other specimens, both dried and in spirit, of the plant are also in that Institution under another earlier and unpublished name, all collected at Port Phillip Heads.

Agardh's description of the external habit of the plant is very good, but that of the internal structure is misleading and indeed erroneous; for the frond has not a cortex such as

he describes. The hamate and peltate, or uncinate and lobato-peltate, fibulae which constitute the "cortex" alleged by him to cover the surface of the frond almost to the apex, are merely the normal young branches dichotomously produced at the apices of the branches (fig. 122). These when numerous form a very lax layer of short spherical or ellipsoidal swellings, each rising from its normal supra-dichotomial constriction; but it is only when observed in their natural position on an undissected frond that they could possibly be mistaken for a cortex. If the filaments are teased asunder the true character of these swellings is at once revealed. Agardh, it will be observed, uses almost the same words describing his so-called "cortex" of *U. peltata* as he uses for the true cortex of the preceding species *U. Desfontainii* (l. c. p. 74).

From a comparison of the two descriptions cited, it is evident that Agardh failed to observe the pseudo-conjugation of short lateral protuberances from adjacent filaments (figs. 120, 121), the fundamental character upon which we base the genus *Rhipiliopsis*. These pseudo-conjugations apparently always remain imperforate, and are only to be found in the upper parts of the filaments. Lower down they have already broken asunder, leaving the protuberances on their respective filaments. These old protuberances are fairly numerous and vary in length.

4. Flabellaria Lamouroux.

(Figs. 29—31; 123—125).

Historical.

The first record of *Flabellaria petiolata* (*Udotea Desfontainii*), the older species of this genus, is to be found in Zannichelli's "De Myriophyllo pelagico" 1714 p. 9 tab. I, where the author figures the species and describes it in the following terms, without designating it by any name: "Herbam videbis, cujus hucusque nemo meminerit, quod sciam, adeoque anony-"mam, Aleyonio innatam, actis inter illius quibus ubique scatet rimulas radicibus. Folia videbis "brevi pedunculo innixa, rotunda, expolita, crassiuscula, leviterque sinuosa; quaeque ad Tussila-"ginem Alpinam secundam Clusii, vel ad Mathaeoli Assarinam accedant. Eorum plura ex unica "protuberant radice, colore viridi, eoque satis vivido. Saporem, odoremque habet cum caeteris "marinis Plantis communem; qua propter Fucis marinis annumerandam, et ex supradictis optime "describi posse censes".

The next mention of this species is in 1725, when Marsilli published his Histoire physique de la mer, in which he describes and figures the plant (p. 64. tabb. VI, VII. figs. 27, 28) under the name of "Mauve marine ou Lactuca laciniata ou Fucus membranaceus". He says: "On decouvre sur la superficie des feuilles, les Glandules ordinaires .... Le pied de la plante "est tout glanduleux, et la superficie de son écorce est semblable au chagrin .... Le pied de la "plante coupé par le travers montre la structure de sa substance, toute de petits Canaux ....".

Giuseppi Gianni Ravennate (Opere postume I. 1755. p. 25. tab. 25. fig. 56) next writes on *F. petiolata* under the name of "Tussillagine dell'Adriatico" and says the plant reminds him of Tussilagine. He gives a good figure of it.

It was in 1813 that Lamouroux (in Ann. Mus. d'Hist. Nat. Paris XX p. 274. tab. 12, fig. 4) instituted the genus *Flabellaria* with one species, *F. Desfontainii* (*Conferva flabelliformis*

Desfontain). As is shown under *Udotea* (p. 100) LAMARCK published in the very next paper to LAMOUROUX's and in the very same volume a new genus also called *Flabellaria* for the reception of ELLIS and SOLANDER's two species *Corallina conglutinata* and *C. Flabellum*, together with some species which now belong to *Halimeda*. LAMARCK regarded his *Flabellaria* as a genus of animals. In 1842 DECAISNE (Ann. Sci. Nat. Bot. 2me série, tom. XVIII. pp. 96—128), having demonstrated the Corallines to be plants, included both *Flabellaria* of LAMOUROUX and *Flabellaria* of LAMARCK in the older genus *Udotea* LAMOUROUX (1812). From 1842 onwards, with a few exceptions which are noted in the list of synonomy of *F. petiolata*, that species has always been classed with *Udotea*, but we now feel ourselves compelled to remove it from that genus and place it with *U. minima* in its old genus *Flabellaria*, for reasons which we give under *F. minima* on p. 48.

Flabellaria Lamouroux 1813 (non Lamarck)
in Ann. Mus. d'Hist. Nat. Paris vol. XX. 1813. p. 274. tab. 12. fig. 4.

Syn. *Udotea* auctorum, pro parte.

Plants green, uncalcified, springing from a rhizome and consisting of caespitose filaments (as in *Chlorodesmis comosa*) or stipitate fronds. Rhizome colourless, horizontal, monosiphonous, branched, radicelliferous.

Stipes usually simple, occasionally forked, green, very rarely calcified below, composed either of a few parallel, slightly twisted, uncorticated dichotomous filaments, or of a few main filaments bearing lateral branchlets subdivided into numerous short, truncate, cylindric apices crowded together into a cortex.

Frond flabellato-rotundate from a cuneate base, thin, faintly zonate, proliferous, margin subentire to ciliate.

Frond filaments monostromatically to distromatically arranged, subcontiguous, radiating from base to margin, either free or slightly held together by a few lateral branchlets or closely covered by a well-developed monostromatic cortex composed of the interlocked sinuate and lobulate apices of the lateral branchlets.

Zoosporangia doubtful, described as lateral, globose, sessile on filaments of frond.

Synopsis of Species.

Plant dimorphic; filaments either arising free in caespitose tufts from the rhizome or uniting to form elementary uncorticated stipitate fronds, often composed of entirely free filaments. . . . . *F. minima.*

Plant consisting of a stipes and frond, both corticated, but margin of frond sometimes ciliated and without cortex. . . . . *F. petiolata.*

1. *Flabellaria minima* nov. comb.

Syn. *Udotea minima* Ernst in Beiheft zum Botanischen Centralblatt XVI. 1904. p. 199. t. 7, 8.
Udotea minima Lotsy Vorträge Bot. Stammesgeschichte I. Jena 1907. p. 61. fig. 33.

Hab. MEDITERRANEAN, Posilipo, Porto della Villa Rendel, on harbour wall, March 1902, *A. Ernst.*

Plants in caespitose tufts 1—2.5 cm. high, green, uncalcified, dimorphic.

Rhizome nodulose, emitting upwards numerous green filaments sparsely and dichotomously branched and either free (just as in *Chlorodesmis comosa*) or combined into stalked flabellate fronds.

Stipes simple or occasionally forked, about 1 cm. long, 0.3—0.6 mm. thick, composed of a few parallel, slightly twisted, uncorticated, dichotomous filaments, expanding cuneately into the frond.

Frond cuneate-flabellate, 1—2 cm. high, 1—1.5 cm. wide, green, sometimes proliferous above, not zonate, composed of free, non-corticated filaments.

Frond-filaments monostromatically arranged, subcontiguous, radiating from base to ciliate margin, in vigorously growing specimens emitting a few lateral branches, which creeping over and among the main filaments serve to bind them together. [Figs. 123—125].

We have not seen this species, but after studying Ernst's long and well illustrated paper (l.c.) we are strongly of opinion that the species is a good one and represents an ancestral stage of *F. petiolata (Udotea Desfontainii)*, a stage characterised by the absence of cortex from both stipes and frond. Further Ernst shews that the plant is dimorphic; besides the somewhat primitive stipitate frond, there is a caespitose growth of free filaments (Ernst loc. cit. taf. 7, fig. 6 = our fig. 123) which in our opinion so much resemble those of *Chlorodesmis comosa*, as to indicate indisputably the direct descent of *F. minima* from an ancestor of the *Chlorodesmis* type, in the same way as the survival of the *Espera* form shows the phylogenetic origin of *Penicillus*. Ernst's fig. 31 (basal filaments and rhizoids) and fig. 22 (torulose ascending filament) are further indications of the close affinity of *Flabellaria minima* with *Chlorodesmis*. (We copy in our figs. 123—125 some of Ernst's figures). We feel ourselves therefore compelled to remove from *Udotea* the two species *U. Desfontainii* and *U. minima*, and place them in a separate genus under the oldest available name — *Flabellaria* Lamouroux (in Ann. Mus. Hist. Nat. Paris XX. 1813. p. 274). Further, according to the Vienna Code the binomial which must be adopted for *U. Desfontainii* is *Flabellaria petiolata*, Turra having published the species as *Ulva petiolata* in his Florae Italicae Prodromus 1758? p. 68 (1780 fide Pritzel).

It may be argued that *F. minima* is merely a growth form of *F. petiolata*, due to environment or to injury by marine animals, and that the poorly developed fronds are merely starved or regenerated states of the better developed *F. petiolata*. But even if this were so it would not explain away the evident and close connection of these two plants with an ancestral *Chlorodesmis*, and their equally evident want of connection with *Udotea javensis (Rhipidosiphon)*, to which all the other species of *Udotea* (which are all calcified, it must be remembered) can be traced (see p. 7).

2 *Flabellaria petiolata* Trevisan

Nomenclator Alg. 1845 p. 19.

Syn. *Ulva* .... *anonymam Alcyonio innatam* .... Zannichelli De Myriophyllo pelagico 1714. p. 6. tab. 1.

Ulva marina Marsilli Histoire physique de la mer 1725 p. 64. tabb. VI, VII, figs. 27, 28.

Tussilagine dell' Adriatico G. Ginanni Ravennate Operc postume I. 1755. p. 25. tab. 25, fig. 56.
Ulva petiolata Turra Florae Italicae Prodromus 1780? p. 68.
Conferva flabelliformis Desfontaines Flora Atlantica vol. II. 1798. p. 430.
Ulva flabelliformis Wulfen Crypt. aquat. 1803. p. 6.
Ulva flabelliformis Roth Cat. 2. 1800. p. 241; and 3. 1806. p. 323. tab. XI. fig. A.
Fucus textilis Roxas-Clemente Ensayo sobre l. variedades. Madrid 1807. p. 319.
Ulva flabelliformis Poiret in Encycl. Méth. 8. 1808. p. 163.
Fucus vitifolius Humboldt et Bonpland Plant. aequinoct. 1808—17. tab. 69, A.
Flabellaria Desfontainii Lamouroux Ess. s. l. genres fam. Thalass. non artic. in Paris Mus. Hist. Nat. Annales vol. XX. 1813. p. 274. tab. 12, fig. 4.
Ulva flabelliformis Sibthorp et Smith Flor. Graec. Prodr. II. 1813. p. 332.
Ulva? flabelliformis De Cand. Flor. Franç. tom. V (vol. VI) 1815. p. 4.
Conferva flabelliforme Blainville in Nouv. Dict. d'Hist. Nat. XI 1817. p. 537.
Fucus flabellum Bertoloni Amoenitates 1819. pp. 223 and 311.
Flabellaria Desfontanii Leman in Dict. Sci. Nat. XVII 1820. p. 92.
Agardhia textilis Cabr. in Phys. Sällsk. Årsb. *fide* Agardh.
Caulerpa? vitifolia Agardh Species Algarum I. 1823. p. 445.
Codium flabelliforme Agardh Systema Algarum 1824 p. 177; et Species Algarum 1823. p. 455.
Codium membranaceum Agardh Systema Algarum 1824. p. 177; et Species Algarum 1823. p. 456.
Ulva flabelliformis Pollini Flor. Veronensis III. 1824. p. 511.
Zonaria? vitifolia Steudel Nomencl. Botan. Crypt. 1824. pp. 102, 450.
Codium flabelliforme v. Martens Reise nach Venedig vol. II. 1824. p. 639.
Codium membranaceum v. Martens l. c.
Flabellaria Desfontainii Gaillon in Dict. Sci. Nat. LIII. Strasbourg 1828. p. 374.
Codio ventagliforme Naccari Flora Veneta VI. 1828. p. 69; and Algol. Adriat. 1828. p. 47.
Flabellaria fimbriata Delle Chiaje Hydrophyt. Regn. Neap. Icon. Neapoli 1829. t. 8.
Fucus flabellum Moris Stirp. Sardo. Elench. fasc. III. Carali 1829 p. 24.
Flabellaria Desfontainii Duby Bot. Gall. 2. 1830. p. 956.
Udotea flabelliformis Blainville Man. d'Actinolog. 1834. p. 558; Atlas tab. 97, fig. 2.
Codium flabelliforme Biasoletto in Isis XXVII. 1834. p. 652.
Codium membranaceum Biasoletto l. c.
Flabellaria Desfontainii Montagne in Ann. Sci. Nat. 2de série X. (Bot.) 1838 p. 272.
Codium membranaceum Corinaldi Elenc. Alg. Mare Labronico. Pisa 1839 p. 71.
Codium flabelliforme Corinaldi l. c.
Flabellaria Zannichellii Zanardini Syn. Alg. Adriat. in Torino Mem. Accad. IV. 1842. p. 227. tab. 5, fig. 1.
Udotea Desfontainii Decaisne Mem. s. l. Corallines etc. in Ann. Sci. Nat. 1842. p. 106.
Flabellaria Desfontainii De Notaris Algol. mar. Ligust. specim. in Accad. d. Sci. Torino ser. 2, tom. IV 1842. p. 228.
Flabellaria Desfontainii Chauvin Recherches. 1842. p. 123.
Flabellaria fimbriata Chauvin l. c.
Codium flabelliforme J. G. Agardh Alg. mar. Medit. et Adriat., Paris 1842. p. 23.
Rhipozonium Desfontainii Kützing Phycologia generalis 1843. p. 309.
Rhipozonium lacinulatum Kützing l. c. tab. 42, fig. 3.
Udotea cyathiformis Endlicher (non Decaisne) Gen. Plant. Suppl. III 1843. p. 17.
Rhipozonium lacinulatum Kützing Phycologia Germanica. Nordhausen. 1845. p. 253.
Rhipozonium Desfontainii Kützing l. c.
Flabellaria Desfontainii Montagne in Cosson et Maisonneuve Flore d'Algérie 1846. p. 51.
Udotea cyathiformis Naegeli (non Decaisne) Neuere Algensystem 1847. p. 177. tab. 2, figs. 25—30.
Olafsenia vitifolia Trevisan in Linnaea XXII. 1849. p. 130.
Chauvinia vitifolia Kützing Species Algarum 1849. p. 499.
Udotea lacinulata Kützing Species Algarum. 1849. p. 503.
Udotea Desfontainii Kützing l. c.

Udotea cuthaformis Payer Botan. Crypt. 1850. p. 32, fig. 140.
Udotea Desfontainii Frauenfeld Algen Dalmatisch. Küste 1855. p. 23. tab. 6.
Udotea lacunulata Frauenfeld loc. cit.
Udotea elata Kützing Tab. Phyc. vol. VII. 1857. tab. 19. fig. a.
Udotea Desfontainii Kützing l. c. tab. 10. fig. b.
Flabellaria Desfontainii Bertoloni Flor. Ital. Crypt. pars II. 1862. p. 46.
Udotea Desfontainii Colmeiro Enum. Crypt. España y Portugal II. 1867. p. 225.
Flabellaria Desfontainii Del Amo y Mora Flor. Crypt. Penins. iberica. Granada 1870. p. 203.
Udotea Desfontainii Ardissone e Strafforello Enum. delle Alghe di Liguria 1877. p. 156.
Udotea flabellariaeformis Wittr. in Botan. Notiser 1880. p. 114.
Udotea Desfontainii Piccone Crociera del Corsaro alle isole Madeira e Canarie 1884. p. 23.
Udotea Desfontainii Hauck Meeresalgen. 1885. p. 481.
Udotea Desfontainii Bizzozero Flora Veneta Crittogamica II. Padova 1885. p. 86.
Udotea lacunulata Bizzozero loc. cit.
Udotea Desfontainii Ardissone Phyc. Medit. II 1886. p. 172.
Udotea Desfontainii De Toni et Levi Flor. Alg. Ven. III. 1888. p. 107.
Udotea Desfontainii J. G. Agardh Till Alg. Syst. V. 1887. p. 74 (excl. syn. *Flab. fimbriata*).
Udotea Desfontainii Askenasy in Forsch. Reise "Gazelle" IV. 1889. Bot. Algen. p. 11.
Caulerpa vittifolia De Toni Syll. Alg. 1889. p. 487.
Udotea Desfontainii De Toni l. c. p. 508.
Udotea Desfontainii Bornet Alg. de Schousboe in Mém. Soc. Nat. Sci. Cherbourg XXVIII. 1892. p. 218.
Udotea Desfontainii Debray Catalogue des Algues du Maroc, d'Algérie et de Tunisie. 1897. p. 32.
Udotea Desfontainii Lotsy Vortrage Bot. Stammesgeschichte I. Jena 1907. p. 61. figs. 33, 34.

Hab. MEDITERRANEAN. "Mediterranean", *Lamouroux*! in Herb. Mus. Paris (sub "*Flabellaria Desfontainii* Lam." and "*Conferva flabellata* Desfont." in Lamouroux's own writing). — Rade de Bône, *Steinheil* in Herb. Mus. Paris! — Nice, *Herb. Lebel*! in Herb. Mus. Paris; also in *Herb. Mus. Paris*! (sub nom. "*Codium flabelliforme*" in J. G. Agardh's writing); also sine loc. ex *Herb. Ad. Brongniart* in Herb. Mus. Paris! — Mediterranean, *Mrs. Merrifield*! also *Desmazières*, Plant. Cryptog. de France Ed. 1. sér. 1. n° 204! and Ed. 2. n° 804! — Marseilles, *Herb. Mus. Brit*!; also Algae Schousboeanae, n° 83! *Hohenacker* n° 104! — Toulon, *Roberts* in Herb. Roem.! — Antibes, *Herb. Dickie*! — Nice, *J. G. Agardh*! — Villa Franca, *Herb. Collins*! — Albisola, *Piccone* in Hauck & Richter Phyk. univ. n° 62! also in Erb. Crittog. Ital. n° 282! also in Rabenhorst Alg. Eur. n° 1295! — Rapallo, *Gepp*! — Spezia, *Weber van Bosse*! — Lunae Portus, Gulf of Spezia, *Bertoloni* in Herb. Roem.! — Livorno, *Arcangeli*! — Nisita, Naples, *Cramer*! — Capri, *Naegeli*! — Bastia, Corsica, *Debeaux* in Flora exsicc. C. Billot n° 4100! — Ajaccio, *Börgesen*! — Corsica, *Soleirol*! — Balearic Islands, *Lindahl* in Alg. exsicc. Wittrock & Nordstedt n° 342! (sub nom. "*U. flabelliformis* Wittr.") — Trapani, Sicily, *Langenbach*! — Adriatic. *Herb. Kützing*! — Venice, *Contarini*! — Adria, *Herb. Kützing*! — Pirano, *Weber van Bosse* in Herb. Hauck! — Parenzo, *Herb. Weber van Bosse*! — Rovigno, *C. Lucas*! also in *Herb. Collins*! also *Hauck* in Hauck & Richter Phyk. univ. n° 62! also *Hauck* in Herb. Weber van Bosse! — Lessina, *Herb. Kützing*! (sub nom. "*Rhipozonium Desfontainii* n° 34.") — Algiers, *Herb. Kew*!

ATLANTIC. Cadiz, *Börgesen*! in Mus. Bot. Copenhagen. — Canary Islands, Graciosa, 32 fathoms, *von Humboldt*! in Herb. Mus. Paris. — Canary Islands, Lanzerote and Graciosa, *D'Albertis*. — Cape de Verde Islands, Letons Rock, (38 F.) "*Gazelle*" Expedition.

Plants varying in length to about 10 cm., not (or very rarely at base) calcified. Rhizome horizontal, bearing several stipitate fronds; sometimes two or more rhizomes are matted together. Stipes usually simple, occasionally forked, varying to about 5 cm. long and 1—2 mm. thick, flattened above. Filaments resembling those of the frond, but thicker-walled, with the lateral branchlets bearing crowded, short, truncate, cylindric apices.

Frond flabellate or suborbicular, from a usually cuneate base, irregularly proliferous from margin or sometimes from surface, zonate, occasionally striate; dull-green in colour; margin subentire, lacerate, or ciliate.

Frond filaments parallel, radiating upwards, subcontiguous, monostromatically arranged, dichotomously branched, with uneven supra-dichotomial constrictions; bearing lateral branchlets of unequal length at irregular intervals, the heads of which are botryoidly or dendroidly subdivided at the apex into somewhat imbricate lobules. Apical divisions of branchlets interlocked, forming a thin continuous monostromatic cortex. Cortex disappearing towards the margin in fimbriate specimens. [Figs. 29—31].

This species is the well-known *Udotea Desfontainii* of the Mediterranean Sea. For certain cogent reasons we have been compelled to remove it from the genus *Udotea*, where it was ill-placed in company with a series of species all calcified. Those species are, we are convinced, derived from such an ancestral form as *Udotea javensis* (*Rhipidosiphon*); whereas *U. Desfontainii* is congeneric with *Flabellaria minima* (as shown under that species, p. 48), which in its primitive stages manifests a close affinity with *Chlorodesmis comosa*. And *U. Desfontainii* itself varies much in the degree of complexity of its structure. Not infrequently the frond is partially and irregularly destitute of cortex, especially towards the margin; and though the lateral branchlets may be present (Kütz. Phyc. Gen. tab. 42. III.), they fail to develop the lobulate heads, which normally cohere to form the cortex of the frond (fig. 30). Again, the frond may be densely and longly ciliated with a margin of excurrent main filaments, which are quite free from one another, and bear no lateral branchlets (Kütz. Tab. Phyc. VII. tab. 19, *a*.). And finally in cases of regeneration, where the frond has been partially or entirely cut away, Ernst (loc. cit. tab. VII. figs. 15—17) shows that the main filaments of frond or stalk respectively grow out free and destitute of lateral branchlets, indeed much resembling the green free filaments of *Flabellaria minima* and of *Chlorodesmis comosa*.

The synonymy of this species is very extensive and is probably not exhausted in the above list, in the compilation of which we were much helped by Bertoloni's Flora Italica Cryptogama Pars 2. 1862 p. 47. Bertoloni cites there, and also previously in his Amoenitates Ital. 1819. p. 311, two synonyms, viz., *Zannichellia* of Micheli and *Rhipidion* n° 1, of Targioni-Tozzetti, which do not appear to have been published elsewhere.

The species has been referred to at least nine genera, viz., *Ulva*, *Conferva*, *Flabellaria*, *Fucus*, *Agardhia*, *Codium*, *Udotea*, *Rhipozonium*, *Olafsenia* and *Photophobe* (subgenus). Of the many synonyms of this plant the oldest Latin binomial appears to be *Ulva petiolata* Turra (1780?). Consequently the well-known *Udotea Desfontainii*, being now replaced in its old genus *Flabellaria*, must in future be designated as *Flabellaria petiolata*, according to the Vienna code. Indeed this combination (*F. petiolata*) was actually employed in the present sense by Trevisan in his Nomenclator Algarum 1845. p. 19, a work which was never completed, running to 80 pages only and then ceasing abruptly.

Two authors, Endlicher and Naegeli, have fallen into the error of stating *Udotea cyathiformis* of Decaisne (Ann. Sci. Nat. XVIII. 1842, p. 106) to be an equivalent of the

present species. ENDLICHER's error (Gen. Plant. Suppl. III 1843. p. 17) is clearly that of a hurried copyist, since he has united two consecutive species into one, by taking the name of the first (*C. cyathiformis*) and joining it on to the synonymy and habitat (Bône [Algiers]) of the second and failing to see that *C. cyathiformis* Decaisne came from Guadeloupe, and that the plant which was collected at Bône by STEINHEIL was *C. Desfontainii* Decaisne. NAEGELI (Neuere Algensystem 1847. p. 177) probably blundered by accepting ENDLICHER's statement without checking it by direct reference to DECAISNE's paper.

Another piece of erroneous synonymy which requires rectification concerns an old and interesting specimen, to which Dr. M. A. HOWE first called our attention, and which we have recently had the pleasure of examining, namely the type of *Fucus vitifolius* Humboldt & Bonpland (Plant. Aequinoct. 1808—17 tab. 69 A) now preserved in the Muséum d'Histoire Naturelle at Paris. Brought up from a depth of 32 fathoms at La Graciosa (or between the islands of Allegranza and Isola Clara, as the text says) in the Canaries, in "prair. an 7" [Prairial i. e. May 20—June 18] 1799), and being of a fine green colour, it so delighted VON HUMBOLDT, coming as it did from a depth which he believed to be too great for the sun's rays to reach, that he sketched it on the spot. He regarded it as a very curious phenomenon in vegetable physiology and came to the surprising conclusion that it is not only under the influence of the solar rays that "se dépose, dans le parenchyma, cette hydrure de carbone qui paroit être la cause principale de la couleur verte des végétaux".

The plant is unmistakeably identical with our present species and with *Flabellaria Desfontainii*, the type of LAMOUROUX's new genus *Flabellaria*, published strangely enough on p. 274 of the same paper (in Annal. Mus. d'Hist. Nat. Paris XX. 1813) in which LAMOUROUX (loc. cit. p. 283) refers *Fucus vitifolius* to *Caulerpa*. Perhaps he had never seen the actual specimen [he records that it was given to WILLDENOW by v. HUMBOLDT], and was misled by the plate, which is inaccurate in some respects. C. A. AGARDH (Spec. Alg. I. 1823 p. 445) was sharp enough to see from the plate that the plant was a doubtful *Caulerpa*, owing to its lack of a creeping surculus. ENDLICHER (Gen. Suppl. III. 1843, p. 16). when dividing up *Caulerpa* into subgenera, placed *Fucus vitifolius* in a new subgenus *Photophobe* — a name evidently alluding to the supposed darkness of the oceanic depths from which the plant had been obtained by v. HUMBOLDT. TREVISAN also divided up *Caulerpa*, but into genera, in his Caulerpearum Sciagraphia (in Linnaea XXII. 1849, pp. 129—144); and he instituted *Olafsenia* (loc. cit. p. 130) for v. HUMBOLDT's *Fucus vitifolius*, stating that the plant was not to be found in any public collection. Thus he, like LAMOUROUX and ENDLICHER, never saw the plant. KÜTZING (Spec. Alg. 1849 p. 499) cites it as a *Chauvinia* without any query. We believe that its identity with the present species has never been publicly notified. Consequently when D'ALBERTIS collected the same species in the same locality (Crociera del Corsaro alle Isole alla Madera e Canarie 1884, p. 23) some 80 years later, it was believed by PICCONE to be the first record for the Canaries.

The distribution of this species is confined to the Mediterranean, the Canaries and the Cape de Verde Islands.

5. Rhipilia Kützing.
(Figs. 126—136).

Historical.

The genus *Rhipilia* was founded by Kützing in his Tab. Phyc. vol. VIII. 1858 p. 12 tab. 28, for the reception of two species collected in the Antilles and preserved in Herb. Sonder. The first is *R. tomentosa* and the second *R. longicaulis*.

In 1870 both species were transferred to *Avrainvillea* by Mazé & Schramm (Algues de la Guadeloupe Ed. II. 1870—77, pp. 89, 90) as synonyms of *A. sordida* Crn. and *A. sordida* var. *longipes* Crn. respectively.

In 1889, Messrs. Murray and Boodle published (Journ. of Bot. XXVII. 1889. p. 69) an account of the genus *Avrainvillea*, in which they separate *Rhipilia longicaulis* from *Avrainvillea sordida* and transfer it to their *A. longicaulis*. (Further remarks on Kützing's figure of *R. longicaulis* are given under *A. Mazei* and *A. sordida*). On the other hand, the type-species of the genus *Rhipilia*, *R. tomentosa*, is united by Murray and Boodle with *A. laete-virens* Crn. as a species of *Udotea*.

Dr. M. A. Howe published (Bull. Torrey Bot. Club. XXXIV. 1907. p. 512, footnote) a full and excellent re-description of *R. tomentosa*, founded on the co-type, preserved in the Sonder Herbarium at Victoria, Australia. But he follows the example of Messrs. Murray and Boodle and places it in *Udotea*. In the present paper we revive *Rhipilia* as a genus and add to it two new species, one from Barra Grande off Pernambuco, and the other from the Malay Archipelago (Siboga Expedition).

Systematic.

The genus *Rhipilia* has heretofore been represented by a single species *R. tomentosa*, which by Murray and Boodle (in Journal of Botany XXVII. 1889 pp. 72 and 239) and by Howe (in Bull. Torrey Bot. Club XXXIV. 1907 p. 512 footnote) has, as stated above, been referred to *Udotea*. *Udotea* however, as limited in the present monograph (p. 106) comprises calcified flabellate species only; and *Rhipilia* is distinguished from it by its uncalcified spongy habit, its intricated filaments furnished with pseudo-lateral tenaculiferous branchlets, and its absence of cortex. It resembles *Avrainvillea* in being uncalcified, and in having a frond composed of more or less intricated filaments, not enclosed in a definite cortex. But its filaments are much more laxly felted than those of *Avrainvillea*, which genus also differs in possessing no short tenaculiferous branchlets, and in having its dichotomial branches constricted at their very bases. Moreover it is not in *Udotea* nor in *Avrainvillea* that the affinities of *Rhipilia* must be sought, but in *Flabellaria* and *Cladocephalus*. The points of resemblance with the latter genus, which is characterised by the possession of a remarkable pseudo-cortex are stated on p. 58. *Flabellaria* is a genus which we have been compelled to revive for the reception of *Udotea Desfontainii* and *U. minima*, on account of their evident ancestral affinity with *Chlorodesmis* and their lack of affinity with the calcified species of *Udotea*. It contains in

Halicystis minima, a species which we think suggests the ancestry of *Rhipilia*. For the lateral branchlets, which, as I have stated, are emitted in vigorously growing specimens of *H. minima* by the main filaments of the frond and, creeping over and among them, serve to hold them together, much remind us of the tenaculiferous branchlets of *Rhipilia*. We regard *H. minima* as indicating a stage in the development of *Rhipilia* out of the primitive *Chlorodesmis* (see table of affinities on p. 6).

In *Rhipilia* the filaments are loosely interwoven and bear short pseudo-lateral branchlets of varying length, which are terminated by digitate tenacula. These tenacula are either free or are closely applied to adjacent filaments, thus adding strength to the loosely felted frond. Such a method of connection by means of tenacula is unknown in both *Udotea* and *Avrainvillea*.

Many of the tenacula remain unattached and it occurs to us that some of them may quite conceivably act as organs for thrusting asunder the filaments of the feltwork, thereby affording an easier passage for water to stream through the open network and a freer access for light. Otherwise these unattached branchlets appear to have no function. This open-work structure, somewhat similar in function to that found in *Microdictyon*, *Struvea*, *Haloplegma*, *Martensia*, *Claudea*, etc., is most obvious in *R. orientalis*, in which species the tenaculiferous branchlets are longest (see fig. 136). In *R. tenaculosa* the tenacula are so abbreviated that they bind the filaments into a much closer weft, producing a stronger frond, but allowing less freedom for the percolation of water through it. In *R. tomentosa* f. *typica* the frond is thicker and firmer; its strength is largely derived from the felting together of its filaments, resulting in a spongy habit like that of *Avrainvillea*.

Rhipilia is distinguished by the frequent absence of constriction at the base of its branches and branchlets. The filaments of *Rhipilia* show the characteristic stoppers (or introrse annular thickenings of the wall of the filament) common to so many of the Siphoneae. (Fig. 128).

Rhipilia Kutzing

Tab. Phyc. VIII. 1858. p. 12.

Thallus green, without calcareous incrustation, stipitate or subsessile; sometimes arising from a horizontal rhizome: frond either cuneato-flabellate, flabellato-rotundate or excentrically sub-infundibuliformi-peltate, thick to very thin, sometimes zonate, ecorticate, filaments of frond cylindrical, here and there slightly and irregularly thickened, thin-walled, collapsing when dried, very laxly interwoven, repeatedly dichotomously branched, branches often not constricted at their base; many of the branches, remaining more or less short, assume a lateral position and are terminated by a tenaculum or crown of 2—6 short processes, which is either applied to an adjacent filament or remains free.

1. *Rhipilia tomentosa* Kützing

Tab. Phyc. VIII. 1858. p. 12, tab. 28 I.

Syn. *Avrainvillea lactevirens* Crouan ex Mazé & Schramm, Algues de la Guadeloupe ed. II. 1877—77. p. 89.

Rhipilia tomentosa Murray & Boodle in Journ. of Bot. XXVII. 1889. p. 72.
Udotea tomentosa Murray in Journal of Botany XXVII. 1889. p. 239.
Rhipilia tomentosa De Toni Syll. Alg. I. 1889 p. 517.
Udotea tomentosa Howe in Bull. Torrey Bot. Club XXXIV. 1907. p. 512.
Udotea tomentosa Collins in Tufts College Studies vol. II. 1909. p. 394.

Plant varying much in habit, usually solitary, sometimes stout, sometimes thin; stipitate. Stipes simple, 0.5—1.5 cm. long, 0.2—0.4 cm. thick, expanding gradually or suddenly into the frond.

Frond cuneato-flabellate, or rotundato-flabellate, sometimes proliferating after injury, up to 5 cm. in length, sub-ezonate to distinctly zonate; margin entire, fringed, lobed or eroso-lacerate.

Frond-filaments 30—70 μ usually about 50 μ in diameter, being collapsed and flat in dried specimens; pseudo-lateral branchlets rather short, 50—200 μ (usually 100—150 μ) long, fairly frequent but not abundant, occasionally appearing to be truly lateral.

Stipes-filaments mostly similar in character and about 45 μ in diameter, but varying up to 70 μ or more, and here and there emitting rhizoids 15 μ in diameter. [Figs. 126—129].

forma *typica*,

Plant stouter, frond cuneato-flabellate, rather thick, sub-ezonate.

Hab. ATLANTIC. Antilles, *Herb. Kütz.*! — Guadeloupe, Gosier, Pointe Laverdure, *Mazé* n^0 233! sub. nom. *Avrainvillea laetevirens.*

forma *zonata*,

Plant thinner, stipes more slender; frond rotundato-flabellate or reniform, thin, translucently zonate.

Hab. ATLANTIC. West Indies, St. Jan, off Cant Bay, *Börgesen*, n^0 1816! about 15 fathoms; also n^0 2218! 15 fathoms.

This species was first described and figured by KÜTZING (l. c.), but, as has been shown in the historical account of the genus, it was afterwards placed by authors in other genera and for some years has been regarded as belonging to *Udotea*. In the Systematic account p. 53 we give our reasons for reviving the genus *Rhipilia*, the type of which is KÜTZING's *R. tomentosa*. This species has never been recognised in herbaria and, previously to Dr. M. A. HOWE's paper in Bull. Torrey Bot. Club (l. c.), was never adequately described. The reason for this is probably that the two original plants, well figured by KÜTZING (l. c.) have been so inaccessible, one (fig. a. of KÜTZING) having been mislaid in the KÜTZING herbarium and only lately brought to light by the present owner Madame WEBER VAN BOSSE, while the other (fig. a′ of KÜTZING) was preserved in Herb. Sonder at Melbourne, Australia. The first of these plants we have been kindly allowed by Madame WEBER to examine and on that (our fig. 126) we base the diagnosis given above. KÜTZING's figure (his fig. a) of the habit is good though it does not exactly represent the outline of the original plant, which is rather stout and stipitate, with a thick flabellate frond obscurely marked with zones. KÜTZING's figure of the structure is a good enough representation of the loose interweaving of the main filaments of the frond, but though it shows a certain number of T-shaped endings to the branchlets, it does not indicate

clearly enough their *haptered* character. It is probable indeed that KÜTZING did not himself recognise their meaning but regarded these terminations as merely dichotomy or ordinary branching. No allusion is made in his diagnosis to any haptera. (See our figs. 127, 128*a*).

The specimens of *Lenormandia lactevirens* Crn. (l. c.) preserved in the British Museum and Kew Herbaria are nothing but little plants of *R. tomentosa* with short thick stalk. The stout habit and the structure are precisely those of the type. The identity of these two species was first recognised by Messrs. MURRAY and BOODLE.

Dr. BÖRGESEN a few years ago in the Danish West Indies collected a few specimens with a much thinner frond, reniform-flabellate, and translucently zonate. To this form we have given the name *zonata* (fig. 129).

2. *Rhipilia tenaculosa* n. sp.

Syn. *Udotea conglutinata* Dickie in Journal Linn. Soc. (Bot.) XIV. 1874. p. 376.

Hab. ATLANTIC. Brazil, off Barra Grande near Pernambuco, 30 fathoms, Sep. 10. 1873, "*Challenger*" *Expedition*!

Plant thin, light green to full green, stipitate, solitary or a few together on a horizontal rhizome, stipes 1—1.5 cm. long, 0.15—0.2 cm. thick, flattening out above and expanding suddenly into the frond.

Frond up to 0.5 cm. in length and breadth, rotundato-flabellate or subinfundibuliformly and excentrically peltate, thin, fissile, usually distinctly zoned, margin entire, fringed, lobed or lacerate.

Frond-filaments 30—70 μ usually about 40 μ in diam., being collapsed or flat (in dried specimens); lateral branchlets mostly very short, usually about 50 μ but sometimes reaching 100—150 μ, very abundant on main filaments, and apparently truly lateral in most cases.

Filaments of the stipes similar to those of the frond but emitting a few rhizoids. [Figs. 130—133].

This species is founded on specimens collected at a depth of 30 fathoms off the coast of Brazil, and preserved in the British Museum and Kew Herbaria. As may be seen by the diagnosis, they include plants which are rotundate-flabellate (fig. 130), as well as others which are excentrically peltate (fig. 131) in which respect they resemble the habit of *Rhipiliopsis peltata*, *Cladocephalus excentricus* and *Udotea cyathiformis*.

Their structure differs from that of *R. tomentosa* in the slightly more slender character of the frond-filaments and especially in the great abundance and the shortness of the lateral branchlets or tenacula with which the frond-filaments are beset (figs. 132, 133).

In habit, *R. tenaculosa* differs from *R. tomentosa* in often being excentrically peltate, with a slighter stipes, and a thinner, often fissile and, so to speak, threadbare frond.

From the following species *R. tenaculosa* differs in being larger, firmer in texture, more regular in outline and in being composed of thicker filaments with much more numerous and much shorter branchlets.

3. *Rhipilia orientalis* n. sp.

Hab. INDIC. *Siboga Expedition.* Stat. 81. Pulu Sebangkatan, Borneo Bank, 34 m. Coral bottom and *Lithothamnion.* n° 334! — Stat. 149. Lagune of Fau Island, reef!

Plants brownish-green, small, gregarious, stipitate; stipes up to 1 cm. long, 0.1—0.2 cm. thick, expanding above into the frond. Frond small, mostly 1—3 cm. long, 1—2.5 (rarely 4) cm. wide, varying in shape from infundibuliformly and excentrically peltate to cuneately or rotundately flabellate, very thin, translucent, almost like brown-stained muslin, not or rarely zonate, margin fimbriate or lacerate. Frond filaments (spirit-specimens) 30—50 μ in diam., very laxly interwoven; pseudo-lateral branchlets long, varying from 70 to 350 μ, usually about 170 μ, frequent but not abundant; true lateral branchlets rare or absent. [Figs. 134—136].

Until the present time, *Rhipilia* has never been known to occur in the Eastern hemisphere. But, among the algae collected by Madame WEBER VAN BOSSE during the Siboga Expedition, are several specimens of what proves to be a new species of *Rhipilia*. It was collected both on muddy reefs at tide level and also at a depth of 19 fathoms on Borneo Bank; but the two sets of plants show no difference in habit or structure to correspond with this difference in depth.

The plants are brownish, small and have a very thin frond almost like coarse muslin in texture, varying in form, like *R. tenaculosa*, from rotundate-flabellate to excentrically peltate. They are rarely zonate and have a very loose fimbriate margin. When dry and adhering to paper, they sometimes look like a mere smudge (fig. 134).

From both the preceding species *R. orientalis* differs in its brown colour, small size, the exceeding thinness and very loose texture of its frond, and the greater average length of its pseudo-lateral branchlets (figs. 135, 136). From *R. tomentosa* it also differs in often having an excentrically peltate frond with stipes shorter and thinner, and frond filaments more slender. From *R. tenaculosa* it also differs in having pseudo-lateral, rarely lateral, branchlets of very much greater length.

6. Cladocephalus M. A. Howe, emended.

(Figs. 32—35; 137—140).

This genus was founded by Dr. HOWE, in Bull. Torrey Bot. Club XXXII. 1905 p. 569, on a new alga *C. scoparius*, collected by him in shallow water in a tidal pond at Georgetown, Great Exuma, Bahamas. The distinguishing character of *Cladocephalus* is the intricate labyrinthiform nature of the cortex, which is composed of repeatedly divaricato-dichotomous filaments closely interwoven. The author describes it thus (loc. cit. p. 570): "The cortex is formed by "branches originating subdichotomously from the more peripheral members of the medullary "strand and becoming afterwards apparently lateral. These branches then undergo repeated "divaricate forkings with a gradual diminution of diameter until finally they may have only "one-fifth or even one-twelfth the diameter of the filaments of the central strand".

As we have shown in a paper describing the Indian Ocean Algae of Mr. J. STANLEY GARDINER (in Trans. Linn. Soc. (Bot.) ser. 2, vol. VII. 1908, p. 177, and loc. cit. (Zool.) XII.

1909 p. 387), the whole structure of *C. scoparius* Howe (fig. 138) apart from external habit, is in every detail, absolutely and indistinguishably identical with that of *Flabellaria luteo-fusca* Crouan (Guadeloupe, Maze n° 1904) (fig. 33). On the ground of habit however the two species remain distinct, the one being besom-like (fig. 137), the other flabelliform (fig. 32). In *C. scoparius* the medullary filaments of the frond are variously gathered into groups which divide and anastomose irregularly (somewhat recalling the anastomosis of the lobes of *Avrainvillea Réderi* or even of *A. Rawsoni*), all being covered with their corresponding pseudo-cortex; the anastomoses are due to the interlocking of the contiguous cortical coverings of adjacent groups. In *F. luteo-fuscus* (*C. luteo-fuscus* Börgesen) on the other hand the cortex spreads uniformly over the whole flatly expanded mass of the medullary filaments producing an undivided flabelliform frond. In the paper above cited, we described a third species, *C. excentricus*, with infundibuliform frond (fig. 130), collected by Mr. Gardiner in deep water (30—47 fathoms) off the island of Cargados Carajos in the western Indian Ocean.

F. luteo-fusca, was referred to *Udotea* by Murray (in Journal of Botany XXVII. 1889, p. 230) and more recently by Howe (in Bull. Torrey Bot. Club XXXIV. 1907, p. 513). It is however as abundantly distinct from *Udotea* as it is from *Flabellaria*. Its true position is unquestionably in *Cladocephalus*.

Cladocephalus therefore contains three species — *C. scoparius*, *C. luteo-fuscus* and *C. excentricus* — unless indeed the first two of these are conspecific.

Cladocephalus differs from *Udotea* (which in the present monograph we limit to calcified flabelliform species only) by its uncalcified spongy habit and its densely felted filamentous pseudo-cortex arising from branchlets of pseudo-lateral origin. From *Flabellaria* it is also quite distinct in its peculiar cortex, though, as suggested below, it manifests a certain affinity with that genus. From *Avrainvillea* it differs much in structure, not being composed of a uniform felt-work of dichotomous filaments of approximately uniform size and character (as is *Avrainvillea*), but being strongly differentiated into a stratum of large medullary filaments enclosed by an external cortical covering of much branched, tapering, and much interwoven filaments.

We find that *Cladocephalus* has a good deal in common with *Rhipilia*. Both genera are uncalcified, and contain flabelliform and excentrically infundibuliform and zonate species; both are characterised by the absence or infrequency of constrictions immediately above the dichotomies of their filaments; and both produce pseudo-lateral branchlets. It is interesting also to notice that the distribution of each genus is the western Atlantic and the Indian Ocean, and that in each genus the Atlantic species have the thicker and the Indian Ocean species the smaller filaments. On the other hand the differences between the two genera are considerable: *Rhipilia* has no cortical covering; its pseudo-lateral branchlets do not undergo ramification, but remain simple and are terminated by a 2—6-dentate tenaculum or crown. Now, these tenaculiferous branchlets of *Rhipilia* much recall the lateral branchlets which in vigorously growing specimens of *Flabellaria minima* serve to bind together the main filaments of the thallus (see p. 48; fig. 125). And we are strongly inclined to regard *Flabellaria minima* as an indication of the common ancestry of *F. petiolata*, *Rhipilia* and *Cladocephalus*, as indicated in our table of affinities (p. 6).

Cladocephalus Howe

in Bull. Torrey Bot. Club. XXXII. 1905. p. 569.

Cladocephalus Börgesen in Vid. Medd. nat. Foren. Kjöbenh. 1908. p. 44.
Cladocephalus Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 396.
Cladocephalus Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil., Nachträge 1910, p. 128, fig. 66.

Plant uncalcified, green or brown, of varied habit, erect, either scopulaeform, or flabelliform, or excentrically subinfundibuliform. Stipes simple or branched, long or short, stout or slender, corticated, attached at base by a mass of rhizoids; medullary filaments and cortex subsimilar to those of frond.

Frond either deeply divided into an irregular, subcompressed, brushlike capitulum, or undivided, flabelliform, or excentrically subinfundibuliform and zonate.

Main filaments of frond radiating from stipes to periphery, subparallel, dividing dichotomously without constrictions, one branch of each pair carrying on the axis of the main filament, while the other becomes pseudo-lateral, thinner and tapering, and repeatedly and divaricato-dichotomously subdividing, forms its portion of the densely interwoven labyrinthine cortical covering of the frond.

Key to the Species.

Plant scopulaeform or besom-shaped. Medullary filaments 30—75 μ in diam. 1. *C. scoparius.*
Plant flabelliform. Medullary filaments 30—75 μ in diam. . . . . 2. *C. luteo-fuscus.*
Plant excentrically infundibuliform. Medullary filaments 15—25 μ in diameter. 3. *C. excentricus.*

1. *Cladocephalus scoparius* M. A. Howe

in Bull. Torrey Bot. Club XXXII 1905. p. 569, pl. 25 and pl. 26, figs. 11—20.
Cladocephalus scoparius Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 396.
Cladocephalus scoparius Wille in Engler und Prantl, op. cit. p. 129.

Hab. ATLANTIC. West Indies, Bahama Islands, Great Exuma, Georgetown, in a tidal pond, on sandy or muddy bottom in 2—10 dm. of water (low tide), *Howe,* n° 4079! also New Providence, south shore, *Howe* n° 3081.

"Very dark green or nigrescent when living, commonly becoming yellowish-brown, "substramineous or olivaceous on drying, solitary or gregarious, 5—14 cm. high; rhizoids "forming a somewhat bulbous mass; stipes 2—10 cm. high, 3—7 mm. thick, subcylindrical "or somewhat complanate, often alate or canaliculate above, simple or occasionally once or "twice dichotomous, the branches sometimes again connate: capitulum scopiform, varying in "outline from elongate-fusiform or elongate-ellipsoid to obovoid or subspherical, often somewhat "flattened, 3—8 cm. long; branches subcylindrical or complanate, 0.3—2 mm. broad, frequently "connate at points of casual contact, now and then subdenticulate near apices: filaments more "or less fuscous in the older parts, sometimes bright-green in the younger; filaments of the "cortex labyrinthine, lightly torulose when young, the ultimate branches in older parts 6—11 μ "in diameter, finally subhyaline; filaments of medulla cylindrical or lightly and irregularly

"torulose, 30—75 μ in diameter, slightly or not at all constricted just above a dichotomy, "covered by cortex at apices or rarely protruding; stipe similar to the capitulum in structure, "its cortex a little thicker and firmer". [Figs. 137, 138].

The specific values of *C. scoparius* and *C. luteofuscus* are discussed under the latter species.

2. *Cladocephalus luteofuscus* Börgesen

Vidensk. Medd. naturh. Foren. Kjobenh. 1908. p. 44.

Syn. *Bryopsis luteofusca* Crouan in Maze & Schramm Algues de la Guadeloupe 1870—77. p. 88.
Halimeda luteofusca J. G. Agardh Till Alg. Syst. V. 1887. p. 76.
Udotea flavo-fusca De Toni Syll. Alg. I. 1889. p. 512.
Udotea luteofusca Murray in Journ. of Bot. XXVII. 1889. p. 239.
Udotea luteofusca Howe in Bull. Torrey Bot. Club XXXIV. 1907. p. 513.
Cladocephalus luteofuscus A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908. p. 177; and op. cit. (Zool.) XII. 1910. p. 387.
Cladocephalus luteofuscus Collins The Green Algae of North America in Tufts College Studies II. 1909. p. 397.

Hab. ATLANTIC. Guadeloupe, St. Martin, anse du Marigot, dans le sable, *Mazé* n° 1904 in Herb. Mus. Brit.! — also *Mazé* nos 27 and 1403. — Sine loc. *Herb. Chauvin*! St. Thomas, *Börgesen*! in 20—30 meters.

Plants varying in length to about 12 cm., green or brown. Root-mass bulbous to elongate.

Stipes short and simple, or longer and once or twice dichotomously branched, up to 9 cm. long, 2—6 mm. wide; the branches flattened above and expanding gradually into the frond.

Fronds 2—6 cm. long, 1—7 cm. wide, cuneato-flabellate or spathulate, or suborbicular, sometimes zoned; colour dark-green to yellowish-brown; margin subentire to eroso-lacerate; fragile when dry.

Main filaments of frond about 30—75 μ, more or less parallel, orange-brown, cylindrical or irregularly and slightly constricted, repeatedly dichotomously divided at irregular intervals, branchlets pseudo-lateral, of unequal length, thinner, tapering, densely and dichotomously subdivided at the apex. Apical ramelli 6—10 μ in diam., pallid, interwoven into a dense pseudo-cortex.

Filaments of stipes much resembling those of frond. [Figs. 32—35].

No description of this species was published until 1907, when Dr. HOWE (loc. cit.) supplied the deficiency. His diagnosis was drawn from MAZÉ's n° 1403 preserved in the herbarium of Mons. BORNET. Our own description was taken principally from MAZÉ's n° 1904 (fig. 32), of which there are two examples in the herbarium of the British Museum. We also found a specimen of it in Herb. Chauvin, but without name, number or locality: frond-filaments of this plant are shown in fig. 34.

Dr. F. BORGESEN collected a fine example of this species at St. Thomas, West Indies, at a depth of 11—16 fathoms. He discusses it in detail (loc. cit. pp. 39—44), identifying it with *Flabellaria luteo-fusca* Crouan, and comparing it with *C. scoparius* Howe, with which it agrees completely in structure, differing merely in external habit (compare figs. 32 and 137). He regards it as very probable that *C. scoparius* is a form of *C. luteo-fuscus* "developed under

peculiar, most probably unfavourable external conditions of life". He inclines to the view that the peculiar scopulaeform habit of *C. scoparius* is due to desiccation of the tops of the plants through exposure to sun and air during unusually low tides, followed by mechanical tearing along the lines of least resistance, that is, parallel to the main filaments.

It seems to us that there are three main objections to this ingenious theory. Firstly, the plants occur in hundreds in the tidal pool described by Dr. Howe, and at depths of 2—10 dm. of water (low tide). Hence some at least of the plants would escape exposure and desiccation. Yet Dr. Howe evidently did not find any of the plants to be flabellate. Secondly, the solitary plant of *C. scoparius* found by Dr. Howe on the shores of New Providence is not recorded as occurring in a tidal pool. This additional record from another locality is a strong argument in favour of *C. scoparius* representing a valid specific type. Thirdly, the habit of *C. scoparius* is besom-shaped, and by no means suggests a compressed flabelliform origin.

Our own view is that *C. scoparius* and *C. lutco-fuscus* are not conspecific but are separate species by reason of difference of habit.

The distribution of *C. lutco-fuscus*, so far as is known, is confined to the West Indies.

3. *Cladocephalus excentricus* A. & E. S. Gepp

in Trans. Linn. Soc. (Bot.) VII. 1908. p. 177, pl. 23, figs. 14—17; & op. cit. (Zool.) XII. 1909. p. 387, pl. 48, figs. 14—17.

Syn. *Cladocephalus excentricus* Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil., Nachträge 1910, p. 129, fig. 66.

Hab. Indic. Cargados Carajos, 30, 45, and 47 fathoms, *J. Stanley Gardiner*!

Plant bright green, solitary, up to 10 cm. high, quite distinct in habit from the other two species of the genus. Stipes attached at base to calcareous substratum, simple, olivaceous, up to 3 cm. long, terete, solid, 1—2 mm. thick.

Frond unequally infundibuliformly peltate, widely expanded, at first rotundate, later irregularly elliptic or lobate, up to 10 cm. broad, membranaceous, green, zonate.

Medullary filaments radiating from the stipes, light green, 15—25 μ in diam., repeatedly dichotomously branched; branchlets pseudolateral, dichotomously and closely subdivided above, tapering to about 5—10 μ in diam. at their apices; ramelli interwoven to form the pseudocortex. [Figs. 139, 140].

This species differs from the West Indian species in its peltate habit with its frond concave above, and its stipes short, thin and unbranched (fig. 139). In this respect it resembles *Rhipilia tenaculosa*, *Rhipiliopsis peltata*, and *Udotea cyathiformis*. It is also distinguished from the West Indian species of *Cladocephalus* by the closer branching of the medullary filaments of its frond and by their much smaller size (fig. 140); they do not exceed 25 μ in diam.; nor do they exhibit the green or fulvous colour which characterises the frond-filaments of the West Indian species.

This is an East Indian species. It was not found within the area explored by the Siboga

Expedition, its habitat being away to the west. The occurrence of this species in Eastern waters is of much interest. The head-quarters of the genus may be regarded as being in the West Indies, from which the other two species are recorded. The genus has not been found elsewhere.

A similar distribution occurs in *Rhipilia*, two species of which are found in the western tropical Atlantic, and one in the Indian Ocean. *Penicillus* is similar in being mainly West Indian, and it has two representatives in Eastern waters and one in the Mediterranean.

7. Rhipidodesmis gen. nov.

(Figs. 141—143).

Plants filamentous, gregarious, laxly caespitose, uncalcified; below decumbent, colourless and irregularly ramified, very laxly entangled (never densely felted so as to form a spurious stipes); ascending above, viridescent, fastigiately or flabellately ramified towards the apex, evenly constricted above the dichotomies; upper dichotomies approximated.

1. *Rhipidodesmis caespitosa* comb. nov.

Syn. *Chlorodesmis caespitosa* J. G. Agardh Till Alg. Syst. V. 1887. p. 49.
Avrainvillea caespitosa Murray & Boodle in Journal of Botany XXVII. 1889. p. 72, pro parte.
Avrainvillea caespitosa De Toni Syll. Alg. I. 1889. p. 516.

Hab. INDIC. Ceylon, Colombo, *Ferguson* n° 110!

Plants about 3 cm. long, gregarious in wide, lax, green patches; filaments cylindric, decumbent and colourless below, occasionally producing lateral branches, often constricted and furnished with annular or excentric stoppers, and containing much starch; ascending and viridescent above: dichotomial divisions distant below, much more approximate towards apex; apical pseudo-articuli often short, oblong; trichotomy not infrequent; filaments always evenly constricted at the dichotomy or trichotomy, measuring 120—150 μ diam., usually collapsed, about 200 μ when flat. [Figs. 141—143].

Having nothing but the dried material of this plant to examine, we are unable to state whether the successive dichotomies of the filaments are normally at right angles with one another, or whether they occur in one and the same plane and are forced out of position by the crowding of the ramelli. Certainly the apical branchlets do overlap one another to some extent (see fig. 143).

The apical branching of this species distinguishes it generically from *Chlorodesmis comosa*, and suggests its position in a new genus intermediate between *Callipsygma* and *Chlorodesmis*. It resembles the latter genus in its long filamentous habit, and approaches *Callipsygma* (fig. 140) very closely indeed in its green complanato-fastigiate apical ramification (fig. 143), which often shows intensely coloured denser contents. It differs from *Chlorodesmis comosa* in the apical ramification and in not possessing the moniliform and longly radicelliferous basal filaments, and in having much thicker upper filaments (compare fig. 142 with fig. 69).

The terminal or peripheral ramifications of *Rhipidodesmis* and *Callipsygma* suggest in a

humble way a sort of affinity with the monosiphonous genus *Apjohnia*, especially when the latter is seen neatly arranged and flattened in the herbarium. But *Apjohnia* possesses in the basal transverse annular corrugations of its articuli a Valoniaceous character, of which we find no trace in *Rhipidodesmis* and *Callipsygma*.

The distribution of this species is, so far as is known, confined to the Indian Ocean.

8. Callipsygma J. G. Agardh.
(Fig. 144—146).

J. G. Agardh Till Alg. Syst. V. 1887. p. 65; De Toni Syll. Alg. I. 1889. p. 504; Wille in Engler und Prantl natürl. Pflnzenfam. I. Teil, 2. Abteil. 1890. p. 142; also Nachträge 1910. p. 128.

Frond uncalcified, green, complanate, sparingly branched; branches 2.5—3.0 cm. long.

Stipes compressed, dark coloured, almost concealed by a covering of short appressed, flexuose, dichotomously branched, moniliform, green filaments, 100 μ thick.

Stipes and branches emitting laterally from their edges longer, patent, complanately dichotomously divided, green, more sparsely constricted filaments, 5 mm. long, forming a continuous fringe along the edge of the stem and branches, and giving them a zonate plumose appearance. Fringing filaments repeatedly dichotomously divided, evenly constricted at the dichotomies; pseudo-articuli 225—270 μ in diam., 1.5—2.0 mm. long below, shorter above (0.75—1.0 mm.), free but laterally contiguous and arranged almost entirely into narrow, apparently monostromatic flabellules (or into fascicles?). [It is unknown whether the successive dichotomies are in alternate planes or in the same plane].

1. *Callipsygma Wilsoni* J. G. Ag. loc. cit.

Syn. *Callipsygma Wilsoni* A. & E. S. Gepp in Journal of Botany XLIII. (1904) p. 364—366, tab. 467, figs. 5—7.

Hab. INDIC. Australia, Victoria, Port Phillip Heads, Sorrento, 1884, *J. Bracebridge Wilson*!

Characters as in genus [Figs. 144—146].

The systematic position of this genus has yet to be finally determined. J. G. AGARDH (loc. cit.) compared it with an imaginary *Rhipocephalus*, having all its parts flattened into the same plane, in consquence of which fanciful view DE TONI (Syll. Alg. I. 1889, p. 504) and WILLE (in Engler & Prantl's Die natürl. Pflanzenfamilien. I. 2. p. 142 1890) were led to place the genus between *Rhipocephalus* and *Udotea*. The only species of *Rhipocephalus* which AGARDH knew was *R. Phoenix*; and that species consists of a well-developed and thickly calcified terete stipes bearing a head or cone composed of a series of verticillately arranged small, cuneate flabellules, which are often laterally coherent and always calcified, and which consist of a row of contiguous juxtaposed filaments cemented together laterally in one plane.

Callipsygma, as described above, has a very different structure (fig. 144), its green, uncalcified flabellules (fig. 145) being in size and character almost exactly like those of individual plants of *Rhipidodesmis caespitosa* (fig. 141), to which species it is in our opinion most closely

allied. *Callipsygma* is, as it were, a compound of many units of *Rhipidodesmis caespitosa*, borne on a common stalk and branches.

Having only one small dried specimen of *Callipsygma Wilsoni* to examine, we are unable to decide whether the peripheral ramifications are truly flabellules (i. e. with all the dichotomial branches arranged in one plane) or whether they are complanately fastigiate (i. e. with the successive dichotomies arranged in alternate planes, but flattened into pseudo-flabellules). Fresh or pickled material is requisite for the determination of this point.

The genus has only once been collected, viz., one plant, at Port Phillip Heads near Melbourne. It was sent by J. Bracebridge Wilson, the finder, to J. G. Agardh for determination, and is preserved in the Museum at Lund. But we have a branch of the original in the British Museum. In fig. 144 the entire plant is represented.

The type-locality lies just within the limits of the Indian Ocean.

9. Boodleopsis gen. nov.
(Figs. 147—152).

Generic diagnosis. Plant minute, monosiphonous, forming green uncalcified caespitose tufts or felted cushions, consisting of a main axis which divides below into very slender ramifying rhizoids, and gradually tapers above and emits branches and occasionally a few rhizoids at intervals; branches repeatedly dividing dichotomously or sometimes trifurcately or verticillately, divaricately, at short intervals and in alternate planes, and forming an extensive ramification; branchlets constricted at base, all loosely interwoven with their fellows and forming a lax felt-work after the fashion of *Boodlea coacta*.

1. *Boodleopsis siphonacea* n. sp.

Hab. Indic. *Siboga Expedition.* Stat. 86. Dongala Palos-bay, shore. n° 352! dried. — Stat. 91. Muaras-reef! in alcohol.

Plant forming dense flattened cushions, 1—5 cm. in width. Main axis rather concealed by the felt-work of ramuli, about 70 μ in diameter below but varying irregularly, containing starch, walls 10—12 μ thick, pale brown, here and there finely striate; lower branches descending and dividing into slender, laxly and dichotomously branched rhizoids about 10 μ thick; upper branches arising singly or in pairs at irregular intervals from the tapering main axis; these branches repeatedly dividing, sometimes at every joint, sometimes at intervals of two or three joints, in the manner stated above, do not taper but remain fairly uniform in diameter 22—25 μ; ramuli (or internodes between the joints) usually 100—150 μ long, green or colourless, with dense contents or with scattered granules, thin-walled, straight, all constricted at base. Occasionally bearing a few (2—10) very short round prominences, sometimes emitting a lateral ramulus. Figs. 147—152.

This obscure little plant apparently grew on a muddy substratum on Muaras-reef (fig. 147), the Dongala specimens are cleaner. In habit it resembles *Boodlea coacta*, but is much

more slender in the dimensions of its filaments (fig. 150), has no tenacula, and being monosiphonous has of course no affinity with *Boodlea*, which is a genus of Valoniaceae. The real affinity of *Boodleopsis* has still to be found.

The principal character of the genus is the abundant ramification of its branches (fig. 150). This ramification consists of a much repeated, divaricate dichotomy in alternating planes, varied frequently with trichotomies (fig. 152) or rarely verticillate nodes (fig. 151). This ramification is so abundant as to render inconspicuous the humble little-branched main axis (figs. 148, 149). The much-branched, short, straight, slender ramuli are extensively and loosely intricated (figs. 147, 150), somewhat as in the capitulum of *Penicillus pyriformis* or the verticils of *Tydemania expeditionis*. But there the similarity with the two calcified plants ends. The characters of *Boodleopsis* are such as to prevent its inclusion in any previously described genus of Codiaceae. It is a humble, pulvinate little plant, easily overlooked. Its loose structure permits of a ready percolation of water, much as in the diaphanous species of *Rhipilia*.

In connection with the inconspicuous primary filament or main axis mentioned above, it is interesting to compare fig. 180, n° 3, in Oltmanns' Morphologie und Biologie der Algen, Vol. I. 1904, p. 293, where it is shown that *Udotea Desfontainii* (*Flabellaria petiolata* of the present memoir) possesses a very similar horizontal primary axis.

10. Tydemania Weber van Bosse.

(Figs. 153—155).

Ann. Jard. Bot. Buitenzorg 2e sér. vol. II. 1901. p. 139; Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil. Nachträge 1910. p. 129, fig. 67.

Plant large or minute, calcified, composed of a simple or branched, monosiphonous, cylindric, or here and there subtorulose main axis, prostrate and sparsely rooting below and bearing, at short irregular intervals, flabella supported on very short or longer stipites; in the type-species the main axis ascends and bears at regular intervals glomeruli, composed of laxly interwoven ramelli. Fructification unknown.

The flabella of *Tydemania* recall the simpler species of *Udotea*, namely *U. javensis* and *U. glaucescens* and the flabellules of *Rhipocephalus phoenix*; but are readily distinguished, even when detached from the main axis, by the bead-like basal articuli (see figs. 154, 155) and stipites.

The glomeruli (fig. 153) on the other hand are to be compared with small capitula of *Penicillus*, but differ in the intricate entanglement of the constituent ramelli caused by the alternating and divaricate branching (fig. 153*a*), the dichotomies often enclosing more than a right angle. A similar lax entanglement of repeatedly branching ramelli is found in *Boodleopsis* (fig. 150), which however differs totally in its humble pulvinate habit, slender filaments and lack of calcification.

The affinities of *Tydemania* are with *Penicillus* on the one hand and with *Rhipocephalus* and *Udotea* on the other. We regard these genera as all arising from a common ancestor, the stages of the descent being lost, though partly indicated by *Espera* and *Tydemania*.

Tydemania has never developed in itself the corticated compound stipes or rhachis which is found in these other three genera above cited, but has maintained its monosiphonous axis and has specialised in the direction of continued, though regularly interrupted, growth, and in dimorphism of habit. The basal position of the flabella suggests that they are the older possession, and that the glomeruli are a later development of the plant. The interrupted mode of growth suggests an affinity with *Halimeda* (see p. 8).

In 1903 F. Heydrich published (in Flora, Band 92. pp. 97—101, with figs.) a description of *Rudicularia*, a new genus of Valoniaceae from the Loo-choo Islands, which at first sight might be considered to be nearly allied in habit to *Tydemania*. We have not seen the plant; but judging from the description and figures we are convinced that *Rudicularia* has no connection whatever with *Tydemania* nor with the Codiaceae. It has been referred to *Apjohnia* by Wille (in Engler und Prantl's nat. Pflanzenfam. I. Teil, 2. Abteil. Nachträge 1910. pp. 111, 112). But we are inclined to think that Heydrich was right in keeping it distinct from that genus. It is an interesting plant which requires further elucidation.

1. *Tydemania expeditionis* Web. v. Bosse loc. cit.

Tydemania expeditionis Gepp in Trans. Linn. Soc. (Bot.) VII. 1908. p. 174, pro parte; and op. cit. (Zool.) vol. XII. 1909. p. 384, pro parte (figures also excluded).

Hab. Indic. *Siboga* Expedition. Stat. 78. Lumu-Lumu, Borneo bank! — Stat. 79b. Kabala-dua, Borneo bank, on coral reef! — Stat. 91. Muaras-reef, Celebes Sea! — Stat. 149. Lagune of Fau Island, on coral reef! — Stat. 213. Saleyer, reef! — Stat. 239. Banda, reef! — Stat. 312. Saleh Bay, North coast of Sumbawa, 15—29 meters! — de Bril near Macassar, Snackey!

Plants more or less calcified, glaucous green, moderately large, about 12 cm. long, simple or with a few main branches above.

Main axis prostrate below, cylindrical, monosiphonous, straggling, tough, about 400—450 μ thick, now and again putting out branches, some of which put out a few rhizoids, and others which sometimes bear a few lateral flabella at short irregular intervals below, and above always bear a series of glomeruli which arise at intervals of about 1 cm.; the flabella (1—1.5 cm. long) are short-stalked, beaded at base, monostromatic, calcified, and composed of laterally connate dichotomous filaments, which taper from 250 μ at the base to 63 μ at the apices; the glomeruli are often contiguous and are composed of four verticillately arranged branches which divide repeatedly, dichotomously and divaricately in alternate planes and at short distances into a subspheroid tangle of laxly interwoven ramelli [Figs. 153, 154].

This genus was entirely unknown until collected by Madame Weber van Bosse in the East Indian Archipelago during the Siboga Expedition, and published by her in 1901 (loc. cit.). Her plants are mostly large and glomeruliferous (fig. 153), but two or three of them bear at their decumbent base monostromatic flabella in pairs or singly in place of glomeruli, as described above (fig. 154). Had these two diverse forms of ramification not been found arising from one and the same axial filament, they would undoubtedly have been regarded as characteristic of two entirely different genera. The glomerulous state of *Tydemania* somewhat resembles glomerulate

forms of *Nitella* and *Chara*, but is more compact. The mature glomeruli of *Tydemania* are contiguous, are about 1 cm. high and 1—2 cm. broad and arise each at the temporary apex of the growing branch axis, which divides into four equal ascending branchlets (fig. 154, upper node); these branchlets, each dividing by repeated divaricate dichotomies in alternate planes and at short intervals (fig. 153 *a*), combine to produce a globular tangle of laxly interwoven ramuli, which measure 240 μ at base close to the branch-axis and taper to 63 μ at the apices. Subsequently the branch-axis resumes its growth and from a new node 1 cm. higher up produces a fresh glomerulus; and thus a series of six or more glomeruli is formed. This interrupted mode of growth recalls distantly that of *Halimeda*. But the likeness goes no further than the fact of growth by interrupted stages. For in *Tydemania* the growing axis is a single monosiphonous filament, whereas in *Halimeda* there is an axial strand composed of several parallel filaments which at the resting apex of the joint (internode) fuse in special manners characteristic of the various species, preparatory to the formation of a new joint (internode) (confer Journal of Botany XLII. 1904, p. 193).

The geographical distribution of *T. expeditionis* is confined to the Malay Archipelago.

2. *Tydemania Gardineri* n. sp.

Syn. *Tydemania expeditionis* A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908. p. 174, pro parte, pl. 23, figs. 18, 19; and op. cit. (Zool.) vol. XII. 1909. p. 384, pro parte, pl. 48, figs. 18, 19.

Hab. INDIC. Chagos Archipelago, Salomon, on reefs exposed at lowest tide, *J. Stanley Gardiner*!, and Amirante, 44—20 fathoms, *J. Stanley Gardiner*! "*Sealark*" Expedition, 1905.

Plants low, laxly caespitose, calcified. Main axis prostrate, monosiphonous, cylindric, 250—400 μ thick, now and again emitting branches, some which are cylindric and bear rhizoids (which are tough and adhere closely to the substratum), and others which are moniliform and divide trichotomously and then dichotomously 5—6 times, divaricately, at short intervals and in alternate planes, and bear ultimately the flabella on 4—6-beaded stipites (250 μ in diam.); the flabella are monostromatic and composed of laterally connate, dichotomously branched filaments, 50 μ in diam. (rarely 40 μ) above, 200 μ at base, where the articuli are very short. Glomeruli absent. [Fig. 155].

When treating of this plant two years ago (in Trans. Linn. Soc. loc. cit.) we were inclined to regard it as a well-developed example of the flabellate form of *T. expeditionis*; upon further consideration however we are convinced that it is a proper species, and we have much pleasure in naming it after its collector, Prof. J. STANLEY GARDINER. It differs from *T. expeditionis* in habit, in details of ramification, and in geographical distribution. It forms a low laxly caespitose patch 4—7 cm. wide, consisting of hundreds of small calcified flabella about 1 cm. high, springing from one or more prostrate branched main axes, which are firmly attached here and there by rhizoids to the substratum. It shows no trace of glomeruliferous shoots, such as predominate in and are characteristic of *T. expeditionis*. Further, whereas in *T. expeditionis* the flabella are few and borne on very short simple stalks which spring singly

or in pairs directly from the main axis at fairly regular intervals (fig. 154), in *T. Gardineri* on the other hand the flabella are borne on long moniliform filaments 5—6 times divided trichotomously or dichotomously (see fig. 155; see also Trans. Linn. Soc. (Bot.) VII. 1908. tab. 23. fig. 10). In other words, in *T. expeditionis* the flabella arising from a given point on the main axis form a simple group of 2—4, and are short-stalked; while in *T. Gardineri* they form a group of as many as 30—100 and are borne on a much divided ramification of beaded filaments. The diameter of the upper cylindric filaments of the flabella in *T. expeditionis* is not less than 0.3 *μ*, while in *T. Gardineri* it is usually about 50 *μ* and sometimes even 40 *μ*.

T. Gardineri is confined to the western Indian Ocean. It was collected at low tide level in the Chagos Archipelago and in deep water (44—20 fathoms) at Amirante. The absence of glomeruli has therefore no connection with the depth at which the plants grow.

11. Penicillus Lamarck.

(Figs. 156—182).

Historical.

The oldest specimen of *Penicillus* that we have seen was collected by Mark Catesby between the years 1722 and 1726, and is included in a set of his plants from Carolina, Georgia, Florida, Bahamas etc. (Herb. Sloane vol. 232, folio 18, in Herb. Mus. Brit.). It is an average example of *P. capitatus*. It is described in MS. by Solander as follows, in the copy of Ray's Historia Plantarum (III. Suppl. p. 31. 1704) in the Botanical Department of the British Museum: "Conferva bahamensis, filamentis cinereis, dichotomis, in pilam congestis quasi petiolo donatam".

The next record that we can find of *Penicillus* is in Seba's Rerum Naturalium Thesaurus vol. I. 1734. p. 5. tab. I. fig. 10. He calls it "Sceleton Fungi terrestris (Squelette d'un Champignon terrestre)", and describes it as such, together with the skeletons of various fruits. The figure is easily recognised as representing *P. capitatus*. No mention is made as to habitat.

The name of *Corallina Penicillus* was given to this plant by Linnaeus in 1758 (Syst. Nat. X. p. 807 sp. 10); and in 1766 Pallas (Elenchus Zoophytorum 1766 p. 428) claims to have seen *Corallina Penicillus (P. capitatus)* growing gregariously in the American Sea. Linnaeus in the same year gives as the habitat of that species "O[ceano] Asiatico" (Syst. Nat. Ed. XII. reformata, vol. I. 1766. p. 1305), an error which was probably due to the mistake made by Pallas and others in regarding *C. Penicillus* as identical with *Hydra glomerata* Linn., which is an animal from the China Seas. Linnaeus certainly regarded all the Corallines as being animals, because of their calcareous covering (loc. cit. p. 1304, footnote).

Ellis and Solander (Nat. Hist. Zoophyt. 1786 p. 126. tab. 25. figs. 4—6) give a good description and figure of *C. Penicillus*, placing it between the species *C. Phoenix (= Rhipocephalus)* and *C. Pavonium (= Chamaedoris)*. Their figures consist of two plants of natural size and a magnified branch of the capitulum. Two of them, nos. 5 and 6, were subsequently made by Lamouroux (Hist. Polyp. Corall. 1816 p. 258) the foundation for a new species under the specific name of *pyramidalis*.

In 1812 Lamouroux (Mém. class. Polyp. coralligènes non entièrement pierreux, in Nouv. Bull. Sci. Soc. Philomat. Paris. III. 1812. p. 185) founded his genus *Nesaea* on three species of *Corallina* i. e. *C. Penicillus*, *C. Peniculum* and *C. Phoenix*.

In the following year, 1813, Lamarck (Sur les Polypiers empâtés, in Ann. Mus. d'Hist. Nat. 1813 p. 297) took precisely the same three species from *Corallina* and founded on them his genus *Penicillus*, ignoring the work of Lamouroux in 1812. Lamarck describes the specimen in his herbarium on which he founded his genus. It was 5 cm. high and the details of the description exactly fit the plant of "*P. capitatus* Ex Herb. Lamarck", which was lent to us out of the Herbarium of the Paris Museum. Though Lamarck included in his genus the two other species now known as *Chamaedoris annulata* and *Rhipocephalus Phoenix*, he admits that he had never seen either of them.

The foundation of Lamarck's genus *Penicillus* on the same species as Lamouroux's *Nesaea* is the subject of remark by the latter author in 1816 (Hist. Polyp. Corall. flex., pp. 253, 254). (But whether Lamarck knew it or not, the name *Nesaea* had already been brought into use for a genus of Lythrarieae by Commerson in 1789. It is true that both Lamouroux and Lamarck believed they were treating of a genus of animals, so that in those days the double use of the name *Nesaea* may have caused no confusion.) Lamouroux (loc. cit). describes the generic structure of the plants, which he had only seen dried. The following six species are enumerated: *Nesea* (the spelling is here altered by him) *Phoenix*, *N. annulata*, *N. eriophora*, *N. Penicillus*, *N. pyramidalis*, and *N. dumetosa*, of which *N. eriophora*, *N. pyramidalis* and *N. dumetosa* are new. *N. pyramidalis* was founded, as stated above, on two of Ellis and Solander's figures. An interesting note is made both here and in the same author's Exposition méthodique 1821 p. 23, in which emphasis is laid on the size and diameter of the branches, as being a good specific character when united with other differences. Curiously enough, in Exposition méthodique *Nesaea eriophora* is omitted.

Schweigger (Beobacht. auf Naturhist. Reisen 1819 p. 49) was the first to recognise *Penicillus* to be a plant; and he describes its mode of development as being at first a closed tube, from the apex of which a bunch of filaments finally breaks out.

In 1824 another species was added by Lamouroux to the genus *Nesea*, namely *N. nodulosa*, in Freycinet's Voyage, Zool. p. 622 tab. 91 figs. 8—9; and in the same year Deslongchamps (Encyclop. méthodique, Paris, Zoophytes 1824, p. 567) gives the first satisfactory detailed account of the structure, placing *N. annulata* in a separate section from the other species.

Blainville follows in 1834 (Man. d'Actinologie p. 553) with an enumeration of the species of *Penicillus*, explaining that the generic name of Lamarck had prevailed rather than that of Lamouroux, as *Penicillus* is more expressive than *Nesaea*.

In 1841 Kützing (Über die "Polypiers calcifères" des Lamouroux p. 11), apparently ignorant of Lamarck's name *Penicillus*, replaced Lamouroux's name *Nesea* with the high-sounding *Coralliodendron*; and called attention to the fact that the filaments of the capitulum are not septate but are unicellular throughout, since he had been able to convince himself of the unbroken continuity of the inner tube by saturating it with tincture of iodine. The conclusiveness of this experiment was unjustly denied by Montagne in 1845 (Plantes cellulaires exotiques, in

Ann. Sci. nat. XVIII p. 202—3) on the ground that he had succeeded in cutting three parallel longitudinal sections of one and the same filament, and that by microscopical examination he was able to convince himself absolutely of the presence of septa in the middle section, such septa occurring only in the filaments of the capitulum. HARVEY being of the same opinion as MONTAGNE, describes the filaments as articulated, pluricellular and confervoid, and places the genus in Valoniaceae (Nereis Bor.-Amer. III. 1857, p. 44). That KUTZING's view is correct is however readily proved by the use of a modern microscope.

Returning to the year 1842 we note the preliminary diagnosis of MONTAGNE's new species *P. arbuscula* in Prodrom. Phyc. Antarct. p. 14, which in 1845 was described in full and figured in DUMONT D'URVILLE's Voyage au Pole Sud, Bot. vol. I. p. 25, pl. 14 fig. 4. MONTAGNE here adds a long description of the structure of the plant. He describes the "crampons" and says the adhesion of the stipes-filaments is caused by these and not, as LAMOUROUX thought, by a gelatinous matter which in drying glues together the parts where it predominates.

To return once more to 1842. In that year DECAISNE published his Mémoire sur les Corallines, in Ann. Sci. Nat. 2e sér. tom. XVIII. 1842, where on pp. 108—111 he gives an account of *Penicillus*, including eight species in the genus. He divides them into two sections, in the first of which he puts five species, and in the second, under the heading "Articuli "flabellato-coaliti", he places the two species which now constitute the genus *Rhipocephalus*; but oddly enough he includes *P. pyramidalis* in the same group, — an obvious error which is probably due to the misplacement of the above-mentioned heading; for clearly it ought to have been placed a f t e r, instead of before, *P. pyramidalis*.

In 1843 KUTZING (Linnaea XVII p. 95: and Phyc. gen. p. 310, tab. 43, III.) invented yet another new name for the genus, *Corallocephalus*, and included in it three species only, viz: *C. Penicillus*, *C. Oedipus (= P. pyramidalis)* and *C. Peniculum (= Chamaedoris annulata)*. The stem-structure is well figured and the continuity of the tubes at the constrictions is shewn. Here for the first time *Penicillus Phoenix* is separated off into a new genus *Rhipocephalus*.

ENDLICHER (Genera Plantarum Suppl. III. 1843, p. 18) follows DECAISNE in his division of the genus. The first division, to which he gives the name *Haligraphium*, contains DECAISNE's five species with the addition of *P. arbuscula* Montagne. The second division is called *Halipsygma* and, as in DECAISNE's arrangement, includes *P. pyramidalis* as well as *P. oblongus* and *P. Phoenix*. ENDLICHER failed to recognise that *P. pyramidalis* had slipped into the wrong group.

In 1849 KUTZING (Spec. Algarum pp. 505, 506) again describes *Corallocephalus*, this time with eight species: — *C. Penicillus*, *C. elongatus*, *C. pyramidalis*, *C. dumetosus*, *C. Lamourouxii*, *C. granulosus*, *C. arbuscula* and *C. eriophorus*.

In 1857 HARVEY (Nereis Bor.-Amer. III. pp. 44—46) indicates his opinion that *Rhipocephalus* ought not to be separated off from *Penicillus* and he adopts in place of it ENDLICHER's subgenus *Halipsygma*. He regards the species as variable and limits them to three — *P. dumetosus*, *P. capitatus* and *P. Phoenix*. His views on the septate character of the filaments of the capitulum have been mentioned above.

In 1862, WORONIN. (in Ann. Sci. Nat. 4e sér. XVI. 1862 pp. 208—211) demonstrates that *Eyferia* is but a state of *Penicillus*.

Both J. G. Agardh (Till Alg. Syst. V. 1887, pp. 58—65) and De Toni (Sylloge Algarum vol. I. 1889, pp. 500—504) maintain the genera *Penicillus* and *Rhipocephalus* as distinct, and no author would now question their validity.

Finally, Monsieur Bornet (Algues de P. K. A. Schousboe, Paris 1892, in Mém. Soc. nationale Sci. nat. et math. de Cherbourg T. XVIII. 1892 p. 57 (217)) includes *Espera mediterranea* Thur. in the genus *Penicillus*.

Morphological.

External characters. The thallus of *Penicillus* consists of root-mass, stipes and capitulum. The plants grow either singly or together in clumps or in colonies. The local name is "The Merman's Shaving Brush". In herbarium specimens the plant varies from green to white, becoming bleached with age and exposure to light. Sometimes the stipes branches dichotomously (as in *P. dumetosus*), and each branch bears a capitulum; but in other species the stipes is almost always unbranched. The root-mass is composed of long filaments bearing lateral fascicles of long, straight, dichotomously branched rhizoids, which are generally matted together into a compact mass with sand and calcareous débris. The stipes may be cylindrical, or more or less compressed, and varies in length and width, being as a rule broad and compressed in *P. dumetosus* (fig. 156) and narrow and cylindrical in *P. capitatus* (fig. 164). It may taper downwards or rarely upwards. It is always calcified and varies from rigid to more or less soft and compressible, being more or less hollow within as in *P. Lamourouxii* (fig. 162). The surface has sometimes a velvety appearance, as in *P. dumetosus* and *P. pyriformis*, or dull or polished as in other species. (For details of stipes-cortex see p. 75).

The capitulum varies in shape and size. It may be large (10—15 cm.) composed of long, wide, straggling, and but slightly calcified filaments, as in *P. dumetosus*; or short (2 cm.) globose and compact, composed of short, thin, rigid and well calcified filaments as in *P. capitatus*. The filaments of the capitulum may all arise close to the apex of the stipes or they may emerge irregularly at some distance down the stipes as in *P. capitatus* f. *elongatus* (fig. 166), giving the upper part of the stipes a whiskered appearance. The individual filaments branch dichotomously, the points of dichotomy occurring at more or less regular intervals, with the intervening portion of filament free from constrictions; or the filaments may be constricted in a moniliform or bead-like manner, as in *P. nodulosus* (figs. 173, 174). Further, the successive dichotomies always lie in alternate planes, thereby distinguishing *Penicillus* from *Rhipocephalus*, in which the dichotomies of the comal filaments lie in one plane.

Structure. As regards the internal structure of *Penicillus*, we have very little to add to the account given by Montagne in Dumont D'Urville's Voyage au Pole Sud (Botanique vol. I 1845. pp. 26—29. pl. 14. fig. *e—i*). Montagne was in error in figuring and describing the filaments of the capitulum of *P. arbuscula* (= *P. nodulosus*) as being septate (compare our fig. 173*a*); but apart from this we can confirm nearly all that he says. The few main filaments which constitute the skeleton of the stipes are modified into rootlets below and into the free branches of the capitulum above. The main rootlets, 2—10 cm. long, fairly straight,

nodulose above, cylindric below, obtuse at lower end, transparent, are usually simple, but emit on all sides at short intervals throughout their whole length numerous lateral root-hairs, long and transparent, which, branching dichotomously, rapidly taper into very fine fibrils.

As one traces a rootlet up into the stipes, the transition into the typical stipes-filament is gradual. The lateral root-hairs gradually become stouter, thicker and interwoven, and so are replaced by the typical "crampons" or abbreviated dichotomous lateral branchlets, the calcified ends of which contribute with those of adjacent branchlets to form the cortical layer of the stipes (see p. 75). These lateral branchlets have the appearance of standing on a pyramidal base; this is due to the constriction found near the base of all branches except the root-fibrils.

The main filaments of the stipes may be straight or flexuose, cylindric or nodulose, simple or sparingly dichotomous. At the apex of the stipes they lose their lateral branchlets, become packed with granular contents, increase in size and acquire a thicker wall; then emerging from the stipes they branch repeatedly and dichotomously, become more or less calcified and constitute the free filaments of the capitulum. These free filaments as seen in herbarium specimens present the appearance of an inner green tube which has shrunk away from the rigid outer calcified sheath. (This is sometimes less obvious in *P. dumetosus*, in which species the filaments are but slightly calcified.) The outer calcified sheath has the appearance of being perforated (compare fig. 182) by numerous small rounded pores (see p. 102). If examined in a dry state under the microscope these are seen to consist of minute spherical bubble-like chambers (as described by Montagne (loc. cit.) for his *P. arbuscula*) each opening by a minute ostiole in the delicate calcified pellicle that covers them (compare also the further remarks on pp. 6 and 102).

According to Woronine the calcium carbonate does not begin to form upon the filaments of *P. mediterraneus* until the end of the summer, so that the young ends of the filaments stand out green and soft from the hardened calcified thallus of the previous years.

The filaments of *Penicillus* are constricted at intervals, which may be long or short according to the species. The walls at these points become much thickened and often transversely striate on the outside, while communication along the filaments is maintained through a much narrowed opening. Stoppers have been described and figured by Woronine for *P. mediterraneus*, similar to those found in *Codium* (see p. 5).

Development. There are two distinct forms of development in this genus according to whether the formation of the stipes follows or precedes that of the comal filaments. In two of the species, *P. nodulosus* and *P. mediterraneus*, the free filaments which form the primitive capitulum are developed in the young plant immediately above the rhizoids, without any intermediate stipes, the stipes being gradually built up later. This is mentioned by Harvey for *P. arbuscula* (= *P. nodulosus*) Phyc. Austr. vol. I. tab. XXII, and by Woronine for *P. mediterraneus* (Ann. Sci. Nat. 4me sér. XVI. 1862. pp. 208—211). In Kew Herbarium there are specimens of *P. nodulosus* in which the primary ascending filaments or primitive capitulum are fully beaded and gradually produce "crampons" or lateral branchlets. These crampons combine to form a cortex which envelopes and binds together the primary filaments into a compound stipes.

In the West Indian species on the other hand, the stipes is developed early in the young plant and grows to a considerable length (*P. capitatus* f. *elongatus*), perhaps to its full size, and then the filaments, the formation of which has been postponed, develop at the summit of the stipes. We have seen specimens which have a fully developed stipes bearing only a few short, slightly calcified filaments at the apex; and Dr. M. A. Howe from personal observation confirms the fact of the stipes being formed before the capitulum in West Indian species.

The stipes (or rhachis) evidently ceases from its growth when once the capitulum begins to be formed; and therein *Penicillus* differs from *Rhipocephalus*, in which genus the rhachis retains the power of slow continued apical growth for long after the first appearance of the capitulum (see p. 92).

Regeneration. As regards the power of regeneration possessed by *Penicillus*, Miss Elsie Kupper has shown (in Mem. Torrey Bot. Club. XII n° 3. 1907. pp. 227, 228) that plants of *P. capitatus*, when decapitated, produced, after the lapse of about a month, a young head of comal filaments. And the accompanying figure shows that similar filaments had broken out singly or in groups along the stipes.

Habitat. *Penicillus* grows on muddy sand and among débris of coral just below tide limits. Mazé and Schramm (l. c. p. 91) record specimens of it as growing at Guadeloupe in calm water on muddy sand at a depth of 1 meter, and again on reefs in the open or among banks of *Zostera* at a short distance from the shore. Dr. Howe found *P. capitatus* in 3—10 dm. of water at Key West and *P. dumetosus* in mangrove mud near low water mark in Florida. Mrs. Pease whose name is well-known as a collector in the West Indies writes: "*Penicillus* "*dumetosus* grew in some abundance in a pool near Manchioneal. The pool was narrow, with "precipitous tufa walls, which towards the sea closed over the pool in an arch through which "the waves broke heavily. The *Penicillus* grew among eelgrass, in muddy soil covered by a "coating of powdered shell and coral. With it were *P. capitatus*, *Avrainvillea longicaulis* and "*Halimedas*. The *P. dumetosus* looked like miniature groves of carefully trimmed evergreen "trees, grey green in colour". Mrs. Pease in Collins' Algae of Jamaica. Proc. Amer. Acad. XXXVII. Nov. 1901. p. 245.

The colour of living plants varies according to the amount of calcification from a full deep-green to grey-green.

Fructification. No information of a satisfactory character has ever been published about the reproduction of *Penicillus*. The bodies which Woronine observed in *P. mediterraneus* and which with much doubt he suggested might be zoosporangia, need re-investigation. The problem of the propagation of *Penicillus* is one which can only be solved by a careful study of the living plants.

Duchassaing (Animaux Radiaires des Antilles. Paris 1850, pp. 27, 28) has stated that *Nesea* [= *Penicillus*] is propagated by sporules and by propagules. As regards the former he erroneously assumes that the numerous pores in the incrustation, which are sometimes open, sometimes closed, are oviferous capsules. As to the propagules, he describes and figures the development in *Nesea penicellus* [= *P. capitatus*], saying that a surculus, given off by the tufted roots, travels under the sand for a distance of 10—12 inches from the mother-plant,

and then throws up a scaly bud. This soon puts out a tuft of branches above, which dichotomise, and the scales fall off. The propagation is repeated, and thus whole colonies of plants arise connected with one another.

It may be added here that among other problems which await investigation are the distribution of the nuclei, chromatophores, etc., and the meaning and mode of development of the constrictions.

Geographical distribution. *Penicillus* flourishes mainly in the West Indian region of the tropical Atlantic, and indeed *Penicillus* and *Rhipocephalus* are both especially well represented in the Bahamas. One species of *Penicillus* occurs in the Moluccas and in West and North Australia; a new species was collected in the Malay Archipelago by the Siboga Expedition, and another occurs in the Mediterranean. The species are mostly rather local, being confined to their own respective regions. This at least is the case with the West Indian and Mediterranean species. It is however not improbable that *P. nodulosus*, the Indian Ocean species, may be found more widely distributed, and it should be sought on the coral reefs and islands between Ceylon and the coast of Africa as well as in the Red Sea, and perhaps in the Pacific.

Systematic.

The species of *Penicillus* have always been founded on external characters and in the present monograph they are perforce, through scarcity of sufficient anatomical differences, treated on similar lines. The absence of sharp distinctions between some of the species is felt when large collections are examined; and for this reason Harvey, who had collected specimens both in the Tropical Atlantic and the Pacific, considered that only three species can reasonably be maintained, viz., *P. dumetosus*, *P. capitatus*, and *P. arbuscula* (= *P. nodulosus*). All intermediate species would therefore have to be sunk into one or other of the two first mentioned, since *P. nodulosus*, recorded only from the Eastern hemisphere, has a distinct character of its own. This view of the species of *Penicillus* is too limited to be maintained at the present day. Having had the opportunity of examining the types of *Penicillus* in the herbaria of Decaisne and Lamouroux, and the specimens collected in the West Indies by Dr. Marshall A. Howe and others, we have realised that at least two species stand between *P. dumetosus* and *P. capitatus*. One of these intermediates is represented by *P. Lamourouxii* Decne. and the other by *P. pyriformis*. To *P. Lamourouxii* we have added a variety, var. *gracilis* Gepp, which we believe to represent *Nesca pyramidalis* Lamouroux, the type of which, as mentioned below, is non-existent. This new form is almost as nearly related to *P. capitatus* as to *P. Lamourouxii*. As to *P. elongatus* Decne., it approaches so near to *P. capitatus* that we have made it a form of that species.

For the material of *P. pyriformis* and *P. Lamourouxii* var. *gracilis* we are indebted to Dr. Marshall A. Howe, whose algological researches and careful observations in the West Indies are producing many interesting results.

The synopsis of species given on p. 76 is based on the diameter of the filaments of the capitulum and on the character of the stipes-cortex. The habit of each species is charac-

teristic, and, when once learned, affords a ready means of distinction: it is however extremely difficult to define in words, though easily expressed in drawings. A strong systematic character is afforded by the calcified cortex of the stipes in some of the species, when examined under a low power (× 30—40) of the microscope. In two of the species, *P. dumetosus* (fig. 159*a*) and *P. pyriformis* (fig. 171*a*), the stipes-cortex is seen to be caespitoso-papillose, while in all the rest the cortex appears pseudoporose, that is, porous, but with the pores closed by a thin film. The pores are comparatively large in *P. Lamourouxii* and its var. *gracilis* (fig. 163*a*) and *P. nodulosus* (fig. 175*a*), and very small in *P. capitatus* (fig. 168*a*) and *P. mediterraneus* (fig. 180*a*). They are still more minute in *Rhipocephalus phoenix* (fig. 186*a*). These papillae and pores represent the ultimate divisions or apices of the lateral appendages of the main filaments of the stipes, as may be seen after decalcification and dissection.

The absence or presence of bead-like constrictions in the filaments of the head is only useful as a systematic character in dividing *P. nodulosus*, the Australian species, from all the others. In *P. nodulosus* the filaments are constricted in moniliform rows of varied length, while in the rest of the genus such beading occurs but irregularly and much less markedly, and forms no distinctive character.

Up to the present time the fructification of *Penicillus* has not been seen. It is possible that this, should it exist, might add a systematic character to the definition of the species.

Penicillus Lamarck

Sur les Polypiers empâtés, in Ann. Mus. Hist. Nat. Paris XX. 1813. p. 297.

Nesaea Lamouroux Mém. class. Polyp. corall. in Nouv. Bull. Sci. Soc. Philom. Paris III. 1812. p. 185.
Nesea Lamouroux Hist. des Polyp. corall. flex. 1816. p. 253.
Coralliodendron Kützing Über d. Polypiers calcifères des Lamouroux in Öffent. Prüf. Realschule Nordhausen 1841. p. 11.
Penicillus Decaisne in Ann. Sci. Nat. 2e sér. tom. XVIII. 1842. p. 96.
Corallocephalus Kützing in Linnaea XVII. 1843. p. 95; Phycolog. generalis 1843. p. 310.
Poropsis Kützing Tab. Phyc. VI. 1856. p. 29, tab. 85, I.
Espera J. G. Agardh Till Alg. Syst. V. 1887. p. 55.
Penicillus J. G. Agardh op. cit. p. 58.
Espera De Toni Syll. Alg. I. 1889. p. 499.
Penicillus De Toni op. cit. p. 500.
Penicillus Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 391.
Penicillus Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil. 1890. p. 141, fig. 93.

Thallus composed of stipes, capitulum and root-mass. Root-mass fibrous, long, branched, sometimes matted into a dense bulb. Stipes erect, usually terete, encrusted externally, hollow and laxly fibrous within (when dry), composed of numerous unicellular, longitudinal, interwoven filaments, dichotomously branched and bearing lateral appendages, the peripheral endings of which are approximated together to form a cortex, which becomes thickly calcified. Capitulum composed of a more or less dense, brush-like tuft of unicellular free filaments; filaments repeatedly dichotomous in alternating planes, sometimes trichotomous, constricted at base of each branch and elsewhere; branches always spreading, covered with a porous calcareous pellicle.

Key to the species.

I. Plant distinctly differentiated into stipes and capitulum (*Penicillus* proper).

A Constrictions of filaments of capitulum not continuously moniliform below (n°. 1—4 are West Indian.)

Filaments of capitulum 400—800 μ or more in diam., slightly calcified, about as long as stipes, spreading. Surface of stipes caespitoso-papillose under microscope. — 1. *P. dumetosus* (p. 76).

Filaments of capitulum 300—500 μ in diam., calcified, short, erect. Stipes compressible, flattened; surface pseudoporose under microscope. . . . . — 2. *P. Lamourouxii* (p. 78).

Filaments of capitulum 100—300 μ, calcified, crowded. Stipes terete, hard; surface minutely pseudoporose . — 3. *P. capitatus* (p. 81).

Filaments of capitulum 150—200 μ in diam., calcified, interlaced; capitulum pyriform. Stipes usually short, rough, wrinkled, with surface caespitoso-papillose under microscope. . . . . — 4. *P. pyriformis* (p. 85).

Filaments of capitulum 160—200 μ, calcified. (Mediterranean). Stipes with surface minutely pseudoporose. — 6. *P. mediterraneus* (p. 87).

B Constrictions of filaments of capitulum continuously moniliform below, of varying length above. (Indian Ocean). Stipes with surface uneven, spumosely pseudoporose . . . . — 5. *P. nodulosus* (p. 86).

II. Plants not differentiated into stipes and capitulum. (*Espera*).

Ascending filaments 100—120 μ, caespitose. (Mediterranean). . . . . — 6. State of *P. mediterraneus*.

Ascending filaments 90—140 μ. (Malay Archipelago). — 7. *P. Sibogae* (p. 89).

1. *Penicillus dumetosus* Blainville [“*dumetosa*”]

Manuel d'Actinologie. 1834. p. 553.

Syn. *Nesea dumetosa* Lamouroux Hist. Polyp. Corall. flex. 1816. p. 259, tab. VIII, fig. 3 [male depicta].
Nesée en buisson Blainville in Nouv. Dict. d'Hist. Nat. XXII. 1818. p. 583.
Nesea dumetosa Deslongchamps in Encyclopéd. Methodique, Zoophyt. 1824—5. p. 568.
Nesea dumetosa Blainville in Dict. Sci. Nat. XXXIV. 1825. p. 493.
Penicillus dumetosus Decaisne Mém. Corallines in Ann. Sci. Nat. sér. 2. XVIII. 1842. p. 109.
Penicillus dumetosus Endlicher Mant. Bot. Gen. Plant. Suppl. III. 1843. p. 18.
Corallocephalus dumetosus Kutzing Spec. Alg. 1849. p. 506.
Penicillus dumetosus Harvey Nereis Bor.-Amer. III. 1857. p. 44. tab. 53, A.
? *Corallocephalus Lamourouxii* Kutzing Tab. Phyc. VIII. 1858. p. 13, tab. 29, fig. 1 (non Spec. Alg. 1849. p. 506).
Corallocephalus affinis Kutzing Tab. Phyc. VIII. 1858. p. 13, tab. 30.
Penicillus longiarticulatus Crouan in Mazé et Schramm Algues de la Guadeloupe, Ed^n II. 1870—77. p. 91.
Penicillus clavatus Crouan in Maze et Schramm, loc. cit. p. 91.
Penicillus dumetosus Farlow in Proc. Amer. Acad. X. 1875 p. 378; U. S. Fish Comm. Report III. 1876 p. 712.

Penicillus dumetosus J. G. Agardh Till Alg. Syst. V. 1887. p. 61.
Penicillus dumetosus Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Penicillus clavatus Murray loc. cit.
Penicillus dumetosus De Toni Syll. Alg. I. 1889. p. 501.
Penicillus dumetosus Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 392.

Hab. Atlantic. No locality, *Herb. Lamouroux*! (type of *Nesea dumetosa* Lamx.). — Bahamas, *F. M. Rayner*, in Herb. Mus. Brit.! — Bahamas, Bemini Harbour, April 17. 1904, *M. A. Howe*! — Florida, *Farlow* in Mus. Bot. Copenhagen! — Florida, Old Rhodes Key, *Curtiss*! — Florida, Boca Chica Key, *Southwick*, in Herb. Collins! — Key West, *Harvey*! — Florida, Caesar's Creek, south of Elliott's Key, in mangrove mud near low water mark, March 31, 1904, *M. A. Howe* n° 2952! in Herb. Mus. Brit. — Jamaica, Manchioneal, *Pease and Butler* in Phyc. Bor.-Amer. n° 769 pro parte in Herb. Mus. Brit.! — Antilles, Voyage du *Cap. Baudin*, Herb. Mus. Paris! — Antilles (sub nom. "*N. pyramidalis* Lmx.") in *Herb. Decaisne*! — Anguilla, *W. R. Elliott*! — Guadeloupe, St. Martin (Lac Simpson), dans le sable, presqu'au rivage (eaux troubles très salins), *Mazé* n° 166 sub nom. "*Penicillus clavatus*" Crouan! — Guadeloupe, Moule (brisante de la Couronne) *Mazé* 88, 1ère sér.!, 1074!, 1075! (all three sub nom. "*Penicillus longiarticulatus* Crouan").

The largest and coarsest species of the genus. Stipes very variable, 2.5—8.0 cm. long and 5—15 mm. in diameter, often branched, thickened upwards generally compressed, with dull, sometimes rough, calcified surface, which is seen to be caespitoso-papillose under microscope.

Capitulum subglobose, usually green (or faded) when dry, attaining a diameter of 15 cm. or more.

Filaments of capitulum dichotomously branched mostly in alternating planes, sometimes trichotomously branched, loosely spreading, usually flaccid and thinly calcified, collapsed and flat when dry, 400—800 μ or more (usually 500—650 μ in diameter when terete), mostly attaining a length of 4—8 cm. or more, being about as long as the stipes.

Filaments of stipes bearing lateral appendages 3—5 times dichotomously divided and terminated by blunt dactyline apices. [Fig. 156—159].

Penicillus dumetosus in its representative form (fig. 156) is the most clearly marked species of the genus. The stipes is often branched and generally more or less compressed; the filaments of the capitulum are thinly calcified and are long, broad and flaccid (in dried specimens they are green or faded), rarely if ever shewing beadlike constrictions. It varies very much in length of stipes, size of capitulum and diameter of filaments; but as a rule the main characteristics just enumerated hold good and serve to distinguish all representative forms without difficulty.

Lamouroux's type of *Nesea dumetosa*, kindly lent to us by Prof. Lignier, is a small specimen (fig. 157). Its stipes is short and thick, and the filaments flaccid and rather narrow, 400—500 μ (rarely 550 μ), though described by Lamouroux as being more than 1 mm. in diameter (Hist. Polyp. Corall. Flex. 1816. p. 258. tab. VIII, fig. 3). There is however no doubt as to the identity of Lamouroux's plant with *P. dumetosus* as commonly accepted. Lamouroux's figure is a bad one and apt to be misleading. The comal filaments are represented with *Chylocladia*-like joints; however the general outline of the figure agrees with Lamouroux's type-specimen, though the drawing has been reversed in printing.

In Herb. Mus. Paris is a specimen labelled by Decaisne "*Nesea dumetosa* Lamx.! Antilles (Voyage du Cap. Baudin)" — probably representing his idea of *P. dumetosus* in 1842, when he published his account of the genus. It has a short stipes and a dishevelled capitulum. We figure a branched comal filament (fig. 158*a*). There is also in Herb. Mus. Paris another specimen of *P. dumetosus*, but it is labelled "*N. pyramidalis* Lmx." in Lamouroux's handwriting. We discuss it on p. 81. It is a young plant, the comal filaments of which are not as long as the stipes. We figure a branched comal filament (fig. 158*c*).

There is a figure in Kützing's Tab. Phyc. VIII. 1858, which we think ought to be referred to the present species. It is his *Corallocephalus affinis* (op. cit. tab. 30), drawn from a small plant, the stipes of which has been broken off. The comal filaments in the drawing appear to vary from about 500—700 μ, thus agreeing with *P. dumetosus*. Kützing also figures *Corallocephalus Lamourouxii* (op. cit. tab. 29, I.) which has the lax comal habit of a slender plant of *P. dumetosus*, in which species we should certainly place it, but for his statement that the magnified portions of filament alongside the main figure are "100mal vergrössert". This would allow these filaments a diameter of only 150—190 μ — a size which is characteristic of *P. capitatus*. But Kützing's figure has not the habit of *P. capitatus*. Nor has it the habit of *P. Lamourouxii* nor of *P. Lamourouxii* var. *gracilis*. The question is whether his *Corallocephalus Lamourouxii* can be a slender example of *P. dumetosus* with the magnification wrongly stated. We include it with a query under the present species. This drawing of Kützing's (Tab. Phyc. VIII. tab. 29. I.) resembles rather nearly a specimen in the British Museum, namely, Mazé's n° 1074 (sub nom. *Penicillus longiarticulatus*) from Guadeloupe, which has a similar lax coma and an equally slender stem, but has filaments with a diameter varying from 550—700 μ. Another of Mazé's specimens issued sub nom. *P. longiarticulatus*, namely n° 88, 1ère sér., from Guadeloupe, is a dwarf plant, curiously enough very like Kützing's other figure (Tab. Phyc. VIII. tab. 30, *Corallocephalus affinis*) discussed above. Its filaments measure 700 μ. Again another of Mazé's specimens represented in the British Museum is his n° 166 from Guadeloupe, sub nom. *Penicillus clavatus*. It has a long compressed dull stipes with dull papillose cortex, slightly widening upwards, and a short dense coma, the filaments of which measure from 450—500 μ, and are slightly more calcified than is usual in *P. dumetosus*, to which species we refer it.

The name of *P. dumetosus* is not employed at all by Mazé and Schramm in their Algues de la Guadeloupe. Possibly they, or rather Crouan, were driven to invent new names for plants which they would have referred to Lamouroux's *Nesea dumetosa*, had the figure not been so misleading.

The geographical distribution of *P. dumetosus* is the West Indian region, where it is fairly common.

2. *Penicillus Lamourouxii* Decaisne

Mem. sur les Corallines in Ann. Sci. Nat. sér. 2. tom. XVIII 1842. p. 109.

Syn. *Corallina penicillus* Ellis and Solander Nat. Hist. of Zoophytes 1786. p. 126, n° 35 (pro parte), tab. 25, fig. 5.

Nesea pyramidalis Lamouroux Histoire Polypiers Coralligènes flexibles, 1816. p. 258; and Expos. Meth. 1821. p. 23.

Nesea penicillus var. *ramulis crassioribus* Deslongchamps in Encyclop. Méth. Zoophyt. 1824—5. p. 568.
Nesea pyramidalis Blainville Dict. Sci. Nat. XXXIV. 1825. p. 493.
Penicillus pyramidalis Blainville Man. d'Actinolog. 1834. p. 553.
Penicillus pyramidalis Decaisne Mém. sur les Corallines l. c. 1842. p. 109.
Penicillus Lamourouxii Endlicher Mant. Bot. Gen. Plant. Suppl. III. 1843. p. 18.
Corallocephalus Oedipus Kützing Phyc. Gen. 1843. p. 310.
Corallocephalus pyramidalis Kützing Spec. Alg. 1849. p. 506.
Corallocephalus Lamourouxii Kützing Spec. Alg. 1849. p. 506. (non Tab. Phyc. VIII. 1858. tab. 29, I.)
Penicillus Lamourouxii De Toni Syll. Alg. I. 1889. p. 502.
Penicillus Lamourouxii A. & E. S. Gepp in Journ. of Bot. XLIII. 1905. p. 2.
Penicillus Lamourouxii Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 392.

forma *typica*.

Hab. Atlantic. West Indies, Banc de Bahama, *Herb. Lamouroux*, type of *P. Lamourouxii* Decne.! — Bahamas, Great Exuma, Georgetown, *Howe*, n° 4081! — No locality, *Herb. Chauvin*, sub nom. *Corallocephalus dumetosus*! — Annato Bay, Jamaica, *Pease and Butler* in Herb. Collins!

var. *gracilis*. A. & E. S. Gepp

in Journ. of Botany XLIII, 1905, p. 2.
Penicillus Lamourouxii var. *gracilis* Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 393.

Hab. Atlantic. Florida, Key West, in 3—10 dm. of water at low tide, Oct. 25. 1902, *M. A. Howe* n° 1412*b*! — Florida, Tarpon Key, *Curtiss* in Herb. Mus. Brit.! — Bahama Bank, *Rayner* in Herb. Mus. Brit.! — Bahamas, Bemini Harbour, with other species of *Penicillus* and *Rhipocephalus*, Apr. 16. 1904, *M. A. Howe* n° 3238! — Bahamas, Fort George Cay, Caicos Islands, *Howe* in Phyc. Bor. Amer. n° 1476! — West Indies, *Scrivener Collection* in Herb. Mus. Brit.! — Manchioneal, Jamaica, *Pease and Butler* in Phyc. Bor. Amer. n° 769! — St. Croix, *Börgesen* in Herb. Börgesen!

Stipes unbranched, rather short, 25—40 mm. in length, 5—8 mm. in diameter, usually compressed, rarely subcanaliculate on one side when dry, thickly encrusted, smooth, hollow, soft and compressible, not penetrating into the capitulum. Surface of stipes appearing pseudoporose under microscope.

Capitulum springing from apex of stipes, often globose, about 2—5 cm. in diameter.

Filaments of capitulum rigid, ascending, well calcified, about 300—500 μ in diameter, constricted at unequal intervals, often globosely constricted below the dichotomy.

Filaments of stipes bearing lateral appendages which are 3—4 times dichotomously divided and terminated by short truncate apices. [Figs. 160—163].

forma *typica*.

Capitulum composed of sparse filaments, mostly 400—500 μ thick.

var. *gracilis*.

Capitulum usually larger, denser, filaments of the capitulum twice as numerous as in the type and more slender (300—400 μ, rarely 450 μ thick), ascending, much calcified, and very slightly entangled.

The type of this species is stated by Decaisne to be "*Vesca dumetosa* var." in Herb. Lamouroux and to have been collected at Bahama.

We have found in Herb. Lamouroux a sheet of specimens with the label "*Vesca dumetosa* Banc de Bahama", and with a supplementary slip bearing the pencilled word "*Lamourouxii*" in Decaisne's handwriting. These plants (of which the best specimen is shown in fig. 160) agree precisely with Decaisne's description and unquestionably represent his type. But curiously enough there is in Herb. Mus. Paris a plant of a very different character which is labelled "*Penicillus Lamourouxii* Dne." (in Decaisne's MS.); this however, as is shown under *Rhipocephalus phalloides* (p. 90) is clearly nothing but the lost type of that species with a wrong label attached (see fig. 180).

P. Lamourouxii is distinguished from *P. dumetosus* by the filaments of the capitulum, which are few (in forma *typica*), short, rigid, well-calcified, terete, and ascending, whereas those of *P. dumetosus*, are crowded, long (about as long as the stipes), flaccid, thinly calcified, flattened when dry. Also the surface of the stipes of *P. Lamourouxii* appears pseudoporose under the microscope, whilst that of *P. dumetosus* appears caespitoso-papillose (see p. 74). Further, an examination of the filaments shows that in *P. dumetosus* the constrictions occur at more or less lengthy intervals, while in *P. Lamourouxii* the internodes are shorter and a bead-like constriction is often found just below or above a dichotomy (fig. 161). This is noted by Decaisne in his original description of *P. Lamourouxii*, where he speaks of the filaments as being "haud raro ad dichotomias globoso-contractis".

This species in its typical condition appears to be rare. We have seen four gatherings of it: 1. the original Bahama specimens in Herb. Lamouroux; 2. a sheet of unlocalized specimens in Herb. Chauvin; 3. a single plant in Herb. Collins from Annato Bay, Jamaica; and 4. Dr. Howe's specimen in Herb. Kew. It does not occur in the British Museum. Could it possibly be overlooked by collectors as an abnormal or poor and old specimen?

In some collections of *Penicillus* there is to be found an intermediate plant, the filaments of which are too slight for the typical *P. Lamourouxii* and yet too robust for *P. capitatus*. This we have described in Journal of Botany XLIII, 1905, p. 2, tab. 468, fig. 2, as *P. Lamourouxii* var. *gracilis*, the type of which is Dr. Howe's n° 1412*b* from Key West, Florida (fig. 162). Its capitulum is dense, the filaments are calcified (except sometimes at the tips) and measure from 300 - 400 μ in diameter; further the stipes is flattened, soft and compressible. It is more common than typical *P. Lamourouxii*, and in herbaria we find it placed under *P. capitatus*, from which it differs in its stouter and less numerous filaments, and its flatter, wider and softer stem, with coarser pseudoporose cortex. In habit it agrees much more closely with *P. Lamourouxii*, differing from it mainly in having much more abundant and slenderer filaments.

In the British Museum are three unpressed plants which must be placed under this new form. One of these was collected on the Bahama bank by F. M. Rayner; the other two are from the West Indies and were purchased from Mr. Scrivener. They differ from typical *gracilis* in having a laxer capitulum. They are of special interest, as they appear to us to afford a clue as to the identity of *Vesca pyramidalis* Lamx. Lamouroux founded that species

on tab. 25, fig. 5 of ELLIS and SOLANDER's Natural History of Zoophytes, which forms part of their *Corallina Penicillus*. LAMOUROUX expressly states that he had never seen the actual plant and complains of the difficulty of founding a description on a mere figure. ELLIS and SOLANDER's specimen is we believe no longer in existence; hence it is impossible to make sure what *Nesea pyramidalis* really is. If ELLIS and SOLANDER's fig. 5 is an accurate representation, we believe that we have found in the RAYNER plant, mentioned above, a clue to the original specimen. The RAYNER plant exactly corresponds with the figure quoted so far as the capitulum is concerned; but lacks the pyramidal stipes emphasised by LAMOUROUX. This in itself is not of importance; for the figure quoted clearly shows that the stem proper is very short and passes imperceptibly into a large conical mass of matted root-fibres, an abnormal but not uncommon occurrence in the genus. We therefore believe that LAMOUROUX was in error in describing his *Nesea pyramidalis* as having a pyramidal stem; and we consider that the RAYNER and SCRIVENER plants above-mentioned represent *N. pyramidalis* Lamx., i. e. *Penicillus pyramidalis* Decne. Thus *N. pyramidalis* is in our opinion nothing but a lax state of *P. Lamourouxii* var. *gracilis*; but of course we feel that in the absence of the type-specimen it is impossible to be absolutely certain.

We ought to add that in Herb. Decaisne there is a specimen named "*N. pyramidalis* Lmx. (Antilles)" apparently in LAMOUROUX's own writing, to which DECAISNE has added "(DECAISNE!)" to show his approval of the determination. This is however merely a small plant of *P. dumetosus* with a pyramidal mass of matted root-fibres. The flaccid filaments of its capitulum in no way resemble the well-calcified rigid filaments represented in ELLIS and SOLANDER's figure. In diameter they correspond with those of *P. dumetosus* (see pl. XIX, fig. 158*c*) (see also p. 78).

An aberrant form of *P. Lamourouxii* f. *gracilis* is seen in Dr. M. A. HOWE's n° 1748 from Key West. It is a ragged and dishevelled specimen with a short stem and filaments laxly disposed and varying from 6—12 cm. in length.

The geographical distribution of *P. Lamourouxii* is confined to the West Indian region.

3. *Penicillus capitatus* Lamarck

Sur les Polyp. empât. in Ann. Mus. Hist. Nat. Paris XX. 1813. p. 299.

Syn. *Sceleton fungi terrestris* Seba Rerum Natural. Thesaurus I. 1734. p. 5, tab. 1, fig. 10.
Corallina penicillus Linnaeus Syst. Nat. Ed. X. 1758, p. 807. sp. 10.
Corallina penicillus Linnaeus Syst. Nat. Ed. XII reformata, vol. I. 1766. p. 1305.
Corallina penicillus Pallas Elenchus Zoophytorum 1766. p. 428 n° 10.
Corallina penicillus Ellis & Solander Nat. Hist. Zoophytes 1786. p. 126, tab. 25, fig. 4.
Corallina penicillus Gmelin Linn. Syst. Nat. vol. I, part VI. 1790. p. 3843.
Corallina penicillus Bosc Hist. Nat. des Vers (Suites à Buffon) vol. III. 18°. Paris (Déterville) 1802. p. 72.
Nesaea penicillus Lamouroux Mem. Class. Polyp. Corall. in Nouv. Bull. Sci. Soc. Philomat. Paris III. 1812. p. 185.
Penicillus capitatus Lamarck Polyp. empât. in Ann. Mus. Hist. Nat. Paris XX. 1813. p. 299.
? *Nesea eriophora* Lamouroux Hist. des Polyp. Corall. flex. 1816. p. 257.
Nesea penicillus Lamouroux op. cit. p. 258.
Penicillus capitatus Lamarck Anim. sans vert. tom. II. 1816. p. 341.

Corallina penicillus Cuvier Regne Animal IV. 1817. p. 77.
Nesea pinceau Blainville in Nouv. Dict. d'Hist. Nat. vol. XXII. 1818. p. 583.
Penicillus capitatus Schweigger Beobacht. natur.-hist. Reisen 1819. tab. XI, Handb. ungegliedert. Thiere 1820. p. 437.
Nesea penicillus Lamouroux Expos. Méth. 1821. p. 23. tab. 25, fig. 4.
Nesea penicillus Deslongchamps in Encyclop. Méth. Zoophyt. 1824—5. p. 568.
Nesea penicillus Blainville Dict. Sci. Nat. XXXIV. 1825. p. 493.
Nesea eriophora Blainville op. cit. p. 493.
Penicillus capitatus Blainville op. cit. XLI. 1826. p. 50.
Penicillus capitatus Blainville Man. d'Actinolog. 1834. p. 553.
Penicillus capitatus Lamarck Anim. sans vert. Ed. II. tom. II. 1836. p. 525.
Penicillus capitatus Decaisne Mem. Corall. in Ann. Sci. Nat. 2me ser. t. XVIII. 1842. p 109.
Penicillus elongatus Decaisne l. c.
Corallocephalus Penicillus Kutzing Phyc. Gen. 1843. p. 310.
Corallocephalus Penicillus Kutzing Spec. Alg. 1849. p. 505.
Corallocephalus elongatus Kutzing op. cit. p. 505.
? *Corallocephalus eriophorus* Kutzing op. cit. p. 506.
Penicillus capitatus Payer Botan. Crypt. 1850. p. 32, figs. 142, 143.
Nesea penicillus Duchassaing Animaux Radiaires des Antilles. Paris 1850. p. 28, tab. 1, figs. 6, 7.
Corallocephalus barbatus Kutzing Tab. Phyc. VII. 1857. p. 8, tab. 20. II.
Penicillus capitatus Harvey Nereis Bor.-Amer. pt. III. 1857. p. 45.
Corallocephalus eriophorus Kutzing Tab. Phyc. VIII. 1858. p. 13, tab. 29, fig. II.
Penicillus capitatus Maze & Schramm Alg. de la Guadeloupe Ed. II. 1870—77. p. 90.
Penicillus elongatus Mazé & Schramm l. c.
Penicillus capitatus Farlow in Proc. Amer. Acad. X. 1875 p. 378; and U. S. Fish Comm. Report III. 1876 p. 712.
? *Nesea eriophora* Lamour. in J. Agardh Till Alg. Syst. V. 1887. p. 63.
Penicillus capitatus Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Penicillus elongatus Murray in op. cit. p. 238.
Penicillus capitatus Howe in Journ. New York Bot. Garden IX. 1908. p. 124, fig. 17.
Penicillus capitatus Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 392.

Hab. ATLANTIC. Bahamas, sub nom. *Corallina Penicillus*, fide *Ellis & Solander*. — Plantae Bahamenses, 1726, *Catesby*! — Bahamas, *Catesby* in Herb. Sloane vol. 232 fol. 16 and 18! — Bancs de Bahama, sub nom. *Nesea Penicillus* var. *Herb. Lamouroux*! — Bahamas, Quarantine Cay, *Herb. Collins*! — Bahama, Fort George Cay, Caicos Islands, *Howe* in Phyc. Bor. Amer. n° 1475! — Bermuda, "*Challenger*" Expedition! — Bermuda, Tuckerstown, *Farlow* in Herb. Kew! — Bermuda, *Farlow*!, *Fewkes*! in Herb. Collins. — Bermuda, Eli's Harbour, Somerset, in 1—2 ft. of water at low tide, *M. A. Howe*! — Hungry Bay, *M. A. Howe* nos 186! 218! — Bermuda, Spanish Point, n° 172 and in a protected bay, Gibbet Island, in shallow water, *M. A. Howe*! — Key West, *Hooper*, in Alg. Exs. Am. Bor. Farl. Anders. Eaton n° 43 in Herb. Mus. Brit.! (pro parte). — Key West, Oct. 25, 1902, in 3—10 dm. of water, very common, *M. A. Howe* n° 1412! — Jamaica, *Herb. Sloane*, I. fol. 22! — Port Antonio, Jamaica, *Humphrey* in Phyc. Bor. Amer. n° 271!, in Herb. Mus. Brit. — Jamaica, *Humphrey* in Phyc. Bor. Amer. sub nom. "*Udotea conglutinata*" n° 1482! in Herb. Mus. Brit. — Jamaica, Port Antonio, *Pease and Butler* in Hauck & Richter, Phyk. univ. n° 523! — Jamaica, *Herb. Collins*! — Porto Rico, *Sintenis*, A. 67! — Porto Rico, Santurce, San Juan, on muddy bottom in 3 dm. of water at low tide, May 16 1903 *M. A. Howe* n° 1871! — St. Thomas, "*Challenger*" *Expedition*! — St. Croix, *Borgesen* in Herb. Borgesen!, and in Alg. Exs. Wittr. Nordst. Lag. n° 1203! — Leeward Islands, St. Eustatius, haven, 4 fathoms, *Herb. Weber van Bosse*! — Antilles, *Blauner* n° 205! — Guadeloupe, Ste. Anne, *Mazé*, n° 709! — Guadeloupe, *Mazé*, n° 1070 sub nom. *Penicillus elongatus*!, also n° 1237 sub nom. *P. arbusculus* var. *minor* Crn. mscr!, also n° 770 sub nom. *P. Lamourouxii* Dec.! — Guadeloupe, Moule, Vieux-Bourg, Pointe de la

Chapelle, lacunes vaseuses au milieu des madrepores, *Mazé* n° 488*bis* in Herb. Mus. Brit.! — West Indies, *Scrivener* collection in Herb. Mus. Brit.! — "Carolina, Bermuda and Caribees" *Clerk* in Herb. Sloane vol. 318. fol. 48! — "Pl: Centro-Americ." *Oersted* in Mus. Bot. Copenhagen! — No locality, sub nom. "*Nesea Penicillus*" in *Herb. Chauvin*! — No locality, sub nom. "*Nesea penicillus* Lamx. *Penicillus capitatus* Lamk. Coll. de Lamarck" in *Herb. Mus. Paris*! — No locality, *Lord Valentia's* collection in Herb. Mus. Brit.!

forma *elongata*.

Hab. ATLANTIC. Banc de Bahama, *Herb. Lamouroux*! — Bermuda, *Farlow* in Herb. Collins! — Bermuda, in the ponds of Walsingham (having subterranean communication with the sea), *Howe* n° 119! — Key West, *Hooper* in Alg. Exsicc. Am. Bor. Farl. Anders. Eaton, n° 43 (pro parte) in Herb. Mus. Brit.! — Florida, Key West, *Howe* n° 1533! — St. Croix *Börgesen*! — Guadeloupe, Saintes, Anse du Marigot, dans le sable, sub nom. *P. elongatus*, *Mazé*, n° 166, 1ère sér. and n° 1073!

Stipes simple, very rarely branched, of varying length (2.5—14.5 cm.), narrow (3—5 mm.), cylindrical, occasionally becoming wider above, hard, rigid, thickly encrusted, smooth, with surface minutely pseudoporose (under microscope).

Capitulum globose or sometimes oblong, 2—6 cm. in diameter.

Filaments of capitulum densely crowded, slightly entangled, ascending, sometimes spreading below, thickly encrusted, rigid, slender, 100—300 μ in diameter; branchlets sometimes shortly subtorulose or here and there constricted; apices slightly swollen, often subtorulose.

Filaments of stipes bearing lateral appendages 4—5 times dichotomously divided, and terminated by very small short truncate apices. [Figs. 164—168].

forma *typica*.

Corallina Penicillus Ellis and Solander, loc. cit.

Capitulum dense; filaments generally 100—200 μ in diameter. Stipes about 4—8 cm. long, usually not penetrating to middle of capitulum. [Figs. 164, 165, 168].

forma *elongata*.

Penicillus elongatus Decaisne, loc. cit.

Capitulum narrow, oblong, often interrupted or prolonged below; filaments generally 200—300 μ in diameter. Stipes elongate, 5.5—14.5 or more cm. long, penetrating beyond middle of capitulum. [Figs. 166, 167].

P. capitatus is the commonest species of the genus, and was figured in literature as long ago as 1734 by Seba. Though it is apt to vary in the size and shape of the capitulum and the length of the stipes, the specific characters are fairly constant. The filaments are slender, very numerous and well-calcified; and the stipes is thin, hard, rigid and round; is commonly 7—10 cm. long, and very rarely is branched. HARVEY, who admitted only three species in *Penicillus* proper, took a broad view of *P. capitatus*, and, as his herbarium shows, included under this species anything intermediate between it and *P. dumetosus*. The delimitation of the species is simplified by an examination of the stipes, the cortex of which under the microscope (see p. 75) is seen to be minutely pseudoporose (fig. 168*a*), while that of

P. pyriformis is caespitoso-papillose (fig. 171 *a*). But for the stipes-characters, the two species might be sometimes confounded, owing to the similarity of size of the capitulum filaments. *P. Lamouroux.i* var. *gracilis* is distinguished by its hollow compressible stipes and thicker comal filaments.

Among the specimens in Herb. Mus. Paris is a plant of *P. capitatus* Lamarck, "coll. de LAMARCK", labelled by DECAISNE; and this we figure for its historical interest (fig. 164). The stipes is unusually short. The comal filaments have a diameter of 150—200 μ (fig. 165). This form is common in the older collections.

Another state of the species is represented in the British Museum by a diminutive and deceptive specimen (Jamaica, HUMPHREY), published under the name of *Udotea conglutinata* (Phyc. Bor.-Amer. n° 1482) and subsequently referred to *U. cyathiformis* in COLLINS's Green Algae of North America p. 395. It is a small starveling plant of *P. capitatus* with typical pseudoporose stipes-cortex and rather thin free comal filaments (100—150 μ, rarely 200 μ, in diameter). In habit and size of plant it corresponds with *P. mediterraneus*.

Our f. *elongata* is, as may be seen in the diagnosis above, founded on *P. elongatus* Decne. (Mem. sur les Corallines p. 109), the type of which is in Herb. Lamouroux according to DECAISNE. We have found specimens under the name "*Nesea Penicillus* var. Banc de Bahama" in herb. Lamouroux, which exactly fit DECAISNE's description. One of these specimens is represented in fig. 166. The difference between these specimens and typical *P. capitatus* appears to consist in the extent to which the stipes penetrates into the capitulum, and in the thicker comal filaments. In f. *typica* the stipes seldom reaches the middle of the capitulum; in f. *elongata* it penetrates beyond the middle. In other words, the capitulum-filaments arise from the stipes for a greater distance below the apex in f. *elongata* than is the case in f. *typica*. In f. *elongata* subsidiary tufts of filaments sometimes arise from the stipes below the main capitulum (Pl. XIX, fig. 166). This form of *Penicillus* is described and well figured by KÜTZING under the name of *Corallocephalus barbatus* (Tab. Phyc. vol. VII. p. 8, t. 20 fig. 2). The diameter of the filaments of *P. elongatus* Decne. is generally about 200—300 μ (fig. 167), whereas that of typical *P. capitatus* is usually not more than 200 μ (fig. 165). There are however many intermediate links between the two forms which cannot be referred with certainty to either. We are therefore in doubt whether f. *elongata* can really be maintained.

There is sometimes a little difficulty in distinguishing f. *elongata* from old dried specimens of *Rhipocephalus oblongus* with which there is a strong superficial resemblance. The most trustworthy distinguishing feature is that in *Rh. oblongus* the characteristic flabellules can always be found (see fig. 191) in the apical cavity of the capitulum even in battered specimens; and at the bases of these flabellules the dichotomies are closer together than the basal dichotomies of the comal filaments of *P. capitatus* f. *elongata*. This point is more fully discussed under *Rh. oblongus* (p. 98).

KÜTZING has figured a plant in Herb. Sonder under the name of *Corallocephalus crioporus* (Tab. Phyc. VIII. 1858. p. 13, t. 29 fig. II), which, judging from the figure, we believe to be merely an old battered and dishevelled specimen of *P. capitatus*. But whether *Nesea crioporus* Lamx. (Hist. Polyp. Corall. flex. 1816. p. 257) must also be referred to *P. capitatus*

we do not know, since we have not seen the original specimen (Herb. Richard). It is strange that DECAISNE makes no reference to *Nesea eriophora* Lamx. in his monograph. AGARDH's suggestion that it was merged in *P. Lamourouxii* by DECAISNE is untenable. AGARDH had never seen DECAISNE's type of *P. Lamourouxii*. It occurs to us that the type of *N. eriophora* Lamx. may when examined prove to be a specimen of *Rhipocephalus Phoenix* with its comal flabellules so lacerated and disintegrated as to have lost its generic character. There is in the British Museum an ancient specimen (Herb. Samuel Dale) approaching such a condition and presenting in part an appearance of cotton-wool (see p. 97).

The geographical distribution of *P. capitatus* is confined to the region of the West Indies.

4. *Penicillus pyriformis* A. & E. S. Gepp

in Journ. of Bot. XLIII. 1905. p. 1, pl. 468, fig. 1.

Syn. *Penicillus Lamourouxii* Mazé et Schramm Algues de la Guadeloupe 1870—77. p. 91 (pro parte).
Penicillus dumetosus Dickie in Journ. Linn. Soc. (Bot.) XIV. 1874. p. 312.
Penicillus dumetosus Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Penicillus capitatus Murray loc. cit. (pro parte).
Penicillus pyriformis Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 393.

Hab. ATLANTIC. Bahamas, Bemini Harbour, April 16 1904, in 1—8 dm. of water, low tide, with *P. capitatus*, *Rhipocephalus Phoenix*, etc. *M. A. Howe*, n° 3236, in Herb. Mus. Brit.! — Bahamas, Mariguana Island, *Howe*, in Phyc. Bor. Amer. n° 1477! — Bermuda Islands, Eli's Harbour, Somerset, on sandy bottom in 1—2 feet of water at low tide, *Howe* n° 244! — Key West, *Harvey*! and *Hooper* in Farlow, Anderson and Eaton's Alg. Exsicc. Amer. Bor. n° 43 (pro parte) in Mus. Bot. Copenhagen! — St. Thomas, 5—15 fathoms, "*Challenger*" Expedition! and 20 fathoms, Börgesen, n° 1137 (pro parte)! — Guadeloupe, Pointe à Pitre, îlet à Jarry, *Mazé* n° 488 in Herb. Mus. Brit.! — Without locality, *Herb. Sloane*, in Herb. Mus. Brit.! — Without locality, *Lord Valentia*, in Herb. Mus. Brit.!

Stipes short, not running up into capitulum, sometimes branched, 10—30 mm. long, and 6—7 mm. thick, somewhat compressed, with surface uneven, appearing caespitoso-papillose under microscope.

Capitulum pyriform, large, (5—7 cm. long, 3—4.5 cm. wide), sometimes infundibuliform, compact, thick and glaucous-green when dried.

Filaments of capitulum calcified, ascending, matted together, crowded, 150—200 μ in diameter, divaricate, sometimes globosely constricted above or below the dichotomy.

Filaments of stipes bearing lateral appendages 3—4 times dichotomously divided and terminated by tapering acute dactyline apices. [Figs. 169—171].

This species was discovered by Dr. M. A. HOWE in the Bahamas and Bermudas and with his courteous permission was described by us in 1905 (loc. cit.). When growing with other species it can be recognised at once, as Dr. HOWE pointed out to us, by its pyriform shape (fig. 169), the density of the capitulum, the distinct interlacing of the filaments, and sometimes also by its infundibuliform habit. We believe also that the densely papillose cortex of its short thick stipes is an infallible character (fig. 171*a*). The plant occurs in large colonies, and always with the same characters.

In the size and crowding of the filaments it is most nearly allied to *P. capitatus*, from

which it differs much in the short, stout, sometimes branched stipes with papillose cortex, the interwoven divaricately branched filaments, and the constant pyriform shape of the capitulum. If a needle or pin be inserted into the capitulum under a few of the filaments of *P. pyriformis*, they will be found to be too much interlaced to admit of being separated along their length from the rest of the capitulum. (The filament figured in fig. 170 was extracted with considerable difficulty). If the same experiment be tried with a plant of *P. capitatus*, the filaments are easily detached lengthwise from the rest of the capitulum, showing that they are not nearly so densely interlaced. The filaments of *P. pyriformis* are sometimes globosely constricted above or below the dichotomy.

The dried specimens brought by Dr. Howe are very heavy as compared with other species of equal size. This is due, as he pointed out, to the dense mass of matted comal filaments and to the sand which has settled and become entangled among them.

The geographical distribution of *P. pyriformis* is confined to the West Indies.

5. *Penicillus nodulosus* Blainville

Man. d'Actinologie 1834. p. 553; Atlas t. 97, fig. 1.

Syn. *Nesea nodulosa* Lamouroux [haud *granulosa*] in Freycinet Voyage autour du monde. Zoolog. 1824. p. 622, tab. 91, figs. 8, 9.
Nesea nodulosa Deslongchamps in Encyclop. Méth. Zoophyt. 1824—5. p. 569.
Penicillus arbuscula Montagne in D'Urville Voyage au Pôle Sud. Bot. 1842—45. p. 25, tab. 14, fig. 4.
Nesea granulosa Lamour. fide Decaisne in Ann. Sci. Nat. 2me sér. tom. XVIII. 1842. p. 109.
Penicillus granulosus Decaisne loc. cit.
Corallocephalus granulosus Kutzing Species Algarum 1849. p. 506.
Corallocephalus arbuscula Kutzing loc. cit.
Nesea nodulosa Milne Edwards in Cuvier Le Règne Animal. Ed. III. vol. X. 1849? p. 130.
Penicillus arbuscula Montagne Sylloge gen. sp. crypt. 1856. p. 451.
Penicillus arbuscula Harvey Phycologia Australica vol. I. 1858. tab. XXII.
Penicillus arbuscula J. G. Agardh Till Alg. Syst. V. 1887. p. 63.
Penicillus granulosus J. G. Agardh loc. cit.
Penicillus arbuscula De Toni Sylloge Algarum I. 1889. p. 502.
Penicillus granulosus De Toni loc. cit.

Hab. Indic. Baie des chiens marins, Isles Rawak et Vaigiou (sub nom. *Nesea granulosa* et *Nesea nodulosa*), *Freycinet* in Herb. Lamouroux! — Moluccas, *Herb. Chauvin*! — West Australia, Fremantle, *Harvey* Alg. exsicc. n° 564! — West Australia, *Clifton*! — West Australia, Rottnest Island, *Markwell*!
Pacific. Ile Toud, *D'Urville*, herb. Montagne in Herb. Mus. Paris!

Stipes short, not exceeding 3 cm. in length, 2—5 mm. in diam., terete or irregularly compressed, thickly encrusted, sometimes branched. Surface uneven, spumosely pseudoporose.

Capitulum subglobose, 2—6 cm. in diam.

Filaments of capitulum rather densely crowded, calcified, rigid, usually 20—30 mm. long, slender, 300—400 μ in diam., constricted below subtorulosely, and above at frequent but irregular intervals.

Filaments of stipes bearing lateral appendages 3—5 times dichotomously divided and terminated by short capitate or rounded apices. [Figs. 172—175].

This species has hitherto been known in the genus under two names — *P. arbuscula* Mont. and *P. granulosus* Decaisne, both established in the same year 1842. A comparison of the two original plants proves at once that they are the same species. Montagne's plant (fig. 172) was collected by Dumont d'Urville at the Island of Toud amid the Warrior Reefs in Torres Straits. Decaisne's *P. granulosus* was founded, as he says (loc. cit.) on "*Nesea granulosa* Lmx. Uranie. iter. Freycinet. p. 622, tab. 91, fig. 8—9. Hab. in Moluccis". And here we encounter a strange error; for Lamouroux's plant was published and figured as *Nesea nodulosa* (and not as *N. granulosa*), and as such it was quoted by Deslongchamps in 1824—5 and as *N. nedulosa* in "Cuvier's Le Règne Animal" (Disciples' Edition) and also as *Penicillus nodulosus* Blainville in 1834. This last as the oldest specific name must take precedence of the two better known names viz. *P. arbuscula* Mont. and *P. granulosus* Decaisne. The latter was published in August 1842, and *P. arbuscula* in the same year; but, which preceded the other, we have failed to discover. The origin of the name *granulosus* is found in Lamouroux's herbarium; for there, in a cover marked "*Naesea granulosa*", is the very specimen figured as *N. nodulosa* by Lamouroux in 1824. And with it are two labels in Lamouroux's MS.: — 1) "28. Freycinet. *Nesea nodulosa*"; 2) "*Nesæa granulosa*. Freycinet. Baie des chiens marins". Decaisne by a slip employed the MS. name (*granulosa*) instead of the published name. Subsequent authors have perpetuated the error.

P. nodulosus is the most easily distinguished species in the genus. Hitherto it has been recorded from the Eastern hemisphere only, where until now it has been the sole representative of the genus. It is readily recognized by the moniliform constrictions of its comal filaments, which are regularly beaded below, irregularly constricted above (figs. 173, 174). In no other species are the constrictions so abundant or so well-defined as here. In some examples of *P. capitatus* the filaments are slightly beaded; but the constrictions do not occur in numbers of more than 3—4 close together, and they are situated, not at the base, but in the upper part of the filaments. Harvey's Pl. XXII in his "Phycologia Australica", Vol. I is good, except in so far as it represents the filaments as being septate. The cortex of the stipes in *P. nodulosus* is pseudoporose (fig. 175*a*).

As regards the development of *P. nodulosus*, it appears to differ from the West Indian species. These latter apparently form first the stipes, which grows up for some length before producing the normal capitulum. But in *P. nodulosus* the process is different. Harvey (Phyc. Austral. l. pl. XXII) describes it as follows: — "In the young frond the stipes consists of "but two or three filaments, and a strata [? state] of the frond occurs in which there is no "stipes, but the moniliform, confervoid filaments arise directly from the matted root-fibres". Young plants are figured by Harvey (l. c.), and still younger ones are preserved in Kew Herbarium, which latter entirely confirm what Harvey says.

The recorded distribution of the species comprises the Molucca Islands and the North and West Coasts of Australia.

6. *Penicillus mediterraneus* Thuret

ex Bornet Alg. de Schousboe in Mém. Soc. Nat. Sci. Cherbourg. XXVII. 1892. p. 217.
Syn. *Espera mediterranea* Decaisne in Ann. Sci. Nat. 2me sér. tom. XVIII 1842 p. 111.

Bryopsis salicornia De Notaris in Descrizione di Genova e del Genovesato, vol. I, pars II, 1846 Regno Vegetale, pp. 67, 73.
Derbesia salicornia Kutzing Tab. Phyc. VI. 1856 p. 29. tab. 85, I.
Bryopsis salicornia De Notaris fide Kutzing loc. cit. p. 30.
Espera mediterranea Woronine in Ann. Sci. Nat. 4me ser. tom. XVI. 1862 p. 208, pl. 10, 11.
Bryopsis salicornia Woronine loc. cit.
Derbesia mediterranea Colmeiro Enum. Crypt. España y Portugal II. 1867. p. 225.
Espera mediterranea J. G. Agardh Till Alg. Syst. V. 1887 p. 57.
Derbesia mediterranea De Toni Syll. Alg. vol. I. 1889 p. 500.

Forma *typica*

Hab. Mediterranean. Villa Franca, Risso (sub "*Espera mediterranea* Dne". in Decaisne's handwriting), *Herb. Mus. Paris*! — Cannes, *Herb. Thuret*! — Cannes, *Lagerheim* in Wittr. & Nordst. Alg. Exsicc. n° 1019! — Antibes, in *Herb. Mus. Brit.*! — Cannes, Antibes, Nice, and Genoa, *Herb. Thuret*!

forma *perfecta*.

Hab. Mediterranean. Antibes, *Herb. Thuret*!

Plant varying much between a non-stipitate form tufted like *Chlorodesmis* and a stipitate Penicilloid form, both calcified.

forma *typica*.

Plant about 2.5—12.5 cm. high, consisting at base of a densely felted mass of branches and rhizoids, and of a coma of free and radiating filaments above, about 2—2.5 cm. long; basal filaments not encrusted, irregularly branched and emitting slender colourless branched rhizoids; upper filaments lightly encrusted, but green towards apices, repeatedly dichotomously branched, branches constricted at base, about 100—120 μ in diam. [Figs. 176, 177].

forma *perfecta*.

Plant about 2.5—8 cm. high, solitary or two or more arising from a thickened base, stipitate, capitate; stipes 0.5—3.5 cm. long, about 2 mm. thick, simple, terete, hard, thickly encrusted, smooth, appearing minutely pseudoporose under microscope. Capitulum pyriform, obconic or almost globose, about 2—2.5 cm. long, about 1—2 cm. wide; filaments encrusted, about 7 mm. long, 200—160 μ in diam., dichotomously branched. Filaments of stipes bearing lateral appendages 2—3 times dichotomously divided and terminated by very small short truncate apices, approximated together to form a cortex, which is hardened with a calcareous deposit. [Figs. 178—180].

This species has been hitherto placed by most systematists in a separate genus, *Espera*, which was founded by Decaisne (loc. cit.) on a specimen collected by Risso at Villa Franca, and sent to Decaisne by J. G. Agardh (Pl. XX, fig. 176). In the few collections of *P. mediterraneus* that we have seen, there has been no plant which reaches the size of Decaisne's type-specimen, the length of which measures 12.5 cm. It consists of an abnormally large mass composed of a multitude of slightly calcified, free, ascending filaments, arising from a thick, densely matted base.

In 1862, WORONINE made a study of *Espera* and published a paper on the subject in Ann. Sci. Nat. sér. IV. tom. XVI. Bot. p. 208. He discovered large stretches of it spread over the sea-bottom in the neighbourhood of Antibes and he was therefore able to observe the plant in its different stages of development. It is very variable in habit, and only one stage of its growth is represented in DECAISNE's diagnosis.

WORONINE describes the plant in its young condition as consisting of filaments dichotomously branched above and buried at the base in the substratum, and emitting very fine, almost colourless rootlets. The development of the perfect stem is described as follows: "La fronde de l'*Espera* présente à un endroit un gonflement, duquel sortent, vers le haut ainsi que vers le bas, des filaments entièrement libres et qui au commencement ne diffèrent d'abord entre eux d'aucune maniére. Sur les filaments du haut, qui se ramifient dichotomiquement, se montrent des ramuscules latéraux, des crampons, pour mieux dire, lesquels, entrelacés les uns aux autres, relient les filaments de la fronde de l'*Espera* en une tige plus ou moins haute et épaisse, qui n'est rien autre chose que le stipe du *Penicillus*". The filaments of the stem as well as those of the capitulum are figured by WORONINE.

Thanks to the kindness of Mons. BORNET we have been permitted to study the interesting and extensive series of specimens of *Penicillus mediterraneus* preserved in Herb. Thuret, representing numerous stages of growth. No one who has had the privilege of seeing this remarkable series can have any doubt as to the validity of the conclusions arrived at by WORONINE. While the comal branches of the perfect or stipitate form are thickly encrusted, those of f. *typica* are but slightly encrusted, with a porose deposit; and the youngest ramuli are, according to WORONINE, green and destitute of calcification until the approach of winter. WORONINE describes and figures both annular and partial (i. e. lateral) stoppers (cloisons) formed by the ingrowth of the cell-wall in the upper filaments. The sporangia are still unknown.

Though WORONINE claimed that *Espera* is congeneric with *Penicillus*, he omitted in his paper to coin the binomial *Penicillus mediterraneus*. THURET appears to be the authority for that combination. WORONINE also omitted to figure or to describe clearly the perfect *Penicillus* form (fig. 178) of the plant. Consequently J. G. AGARDH, who obviously had seen no example of this perfect form and had to rely upon WORONINE's figures, maintains *Espera* as a separate genus on the erroneous assumption that it has no definite properly-constituted stipes like that of *Penicillus*; but he admits that it stands nearest to *Penicillus*. He also believes that it has an affinity with *Chlorodesmis* in habit. That genus however is distinguished from *Espera* by its total lack of calcification — a distinction of prime importance (see p. 6).

The geographical distribution of *P. mediterraneus* is confined to the south coast of France.

7. *Penicillus Sibogae* n. sp.

Hab. INDIC. *Siboga* Expedition. Stat. 296. Bay of Noimini, South coast of Timor! alcohol specimen.

Plant (immature?) about 1 cm. long, consisting of a solitary branched calcified filament; resembling *Espera* or immature plantlets of *P. nodulosus* but smaller and more slender.

Filament simple, rootlike and uncalcified below, calcified above and branched dichotomously in alternate planes, occasionally trifurcately, slightly inflated below each dichotomy: branches constricted at base and often subtorulose immediately above it and occasionally at intervals along their length, 140—95 μ in diam.; calcareous sheath minutely porose. [Figs. 181, 182].

This species, of which we have seen only one gathering, is mixed with *Udotea javensis* and *U. peltata* and was probably dredged up from between 8 and 36 meters. It appears to be an immature state of a more highly developed species hitherto undescribed and unknown. Had it been possible to maintain Decaisne's *Espera* as an independent genus, we should without hesitation have placed this species in it. But, as Woronine shewed nearly half a century ago, *Espera* is nothing but a state of a species of *Penicillus*, which is now known as *P. mediterraneus*. Our species (fig. 181) so closely resembles in its simple habit small plantlets of the *Espera*-state of *P. mediterraneus* (but differs in having the filaments smaller, frequently beaded and often trichotomous), as to suggest the possibility of its being the *Espera*-state of an Indian Ocean species of *Penicillus*. The only species hitherto recorded from that region is *P. nodulosus* Blainv. (= *P. arbuscula* Mont.), which in its early stage consists of small plantlets of branched and beaded filaments. But the dimensions of those filaments are about 300 μ in diameter, whereas in *P. Sibogae* they are only about 100 μ in diameter, and the beading is less conspicuous. The two plants, though closely allied, are not conspecific, though they may well be congeneric. There are two points of interest in *P. Sibogae* to which attention may be called. In the first place, we find in *P. Sibogae* instances of trifurcate branching, a mode of ramification which occurs also very rarely in *P. dumetosus* and other species, and more commonly in *Boodleopsis* (see also p. 3). In the second place, we have found a solitary instance of lateral cohesion between two adjacent parallel ramuli along a very short distance of their length, viz., 0.5 mm. (Fig. 181 *a*). This most probably is a mere chance conglutination due to the simultaneous calcification of the two filaments which happened to be in close and parallel contiguity. But on the other hand it may possibly point to the formation of simple flabellate fronds in a more mature state of the plant, such as are found in *Tydemania*, *Udotea* and *Rhipocephalus*; but the evidence is far too slender to allow any definite inference to be drawn from it, and we are inclined to regard the said cohesion as accidental. Moreover it must be remembered that the successive dichotomies of *P. Sibogae* occur in alternate planes, a fact which points much more towards the formation of a Penicilloid capitulum than of a Udoteoid flabellum. However it is conceivable that *P. Sibogae*, like *Tydemania*, may have the power of producing both capitulum and flabellum.

Another possibility about *P. Sibogae* is that it may be another such primitive Siphonaceous form as *Chlorodesmis*, from which of course it differs in being calcified and not gregarious. And whereas *Chlorodesmis* indicates the ancestry of *Flabellaria* and other green uncalcified genera, so *P. Sibogae* might indicate the ancestry of some of the calcified genera — for example, *Penicillus*, *Tydemania*, etc.

The geographical distribution is at present limited to Timor in the Indian Ocean.

Species inquirenda.

"*Penicillus? comosus* Crouan in Schramm et Mazé Algues de la Guadeloupe ed. I. "[1865] p. 44, n. 158. — Griseo-viridis; stipite brevi, cylindraceo, incrustato, filamentis nume-"rosis, laxe anastomosantibus, superne in comam subplanam, flabelliformem, intertextam, mar-"gine laciniatam abeuntibus constituto.

"Hab. ad insulam Guadelupam (Mazé). — In editione ejusdem operis altera ne memo-"ratus quidem".

This diagnosis is copied from De Toni's Sylloge Algarum I. p. 503 (1889). We have never been able to see Schramm and Mazé's first edition, nor have we seen any named specimen of the plant. Were it not for the word "anastomosantibus", we should be inclined to refer it to *Udotea conglutinata* or *U. cyathiformis*.

12. Rhipocephalus Kützing.

(Figs. 183—192).

Historical.

The history of the genus *Rhipocephalus* is closely bound up with that of *Penicillus*, from which genus it was separated in 1843. The oldest specimen of which we have cognisance is in the British Museum (see p. 97) and belonged to Samuel Dale who died in 1739. The first of the species mentioned in literature appeared under the name of *Corallina Phoenix* described by Ellis and Solander in their Nat. Hist. Zoophyt. 1786 p. 126. tab. 25. figs. 2, 3, where it is placed with *C. Penicillus*, as we relate in our account of the genus *Penicillus* (p. 68). It then follows the fortunes of *Corallina Penicillus* (*Penicillus capitatus*) through the phases of *Nesaea* and *Penicillus* till Kützing (Phycologia generalis 1843 p. 311), separated it off to form his new genus *Rhipocephalus*. From that time *Rhipocephalus* has maintained its position except at the hands of Mazé and Schramm (Algues de la Guadeloupe p. 87) who call their plant *Udotea Phoenix*, and of Harvey (Ner. Bor.-Amer. III. 1858. p. 46) who was clearly of opinion that *R. Phoenix* should not be separated from *Penicillus* (see under *Penicillus* p. 70 supra).

The second species of the genus was created by Decaisne (Mém. sur les Corall. in Ann. Sci. Nat. XVIII. 1842. p. 109), under the name of *Penicillus oblongus* and was placed with *P. phoenix* and *P. pyramidalis* in a subdivision of *Penicillus* (see p. 70). In 1843 Kützing removed it with *P. phoenix* to *Rhipocephalus*. No other species has ever been added to the genus.

Morphological.

External characters. The thallus of *Rhipocephalus* broadly resembles that of *Penicillus* in habit and structure. It consists of root-mass, stipes and capitulum. The stipes is always simple, terete, firm and calcified, and may be short or long. The capitulum varies very much in shape from ovoid to cylindric, and in size up to 10 cm. long. It is composed of

ascending and imbricating, monomorphic flabellules, arranged normally in subverticils around the rhachis, and varying much in size, being 5—20 mm or more in length. In *R. phoenix* the flabellules of the same pseudo-verticil are usually laterally connate into collars which more or less completely encircle the rhachis. The rhachis appears to have a power of continuous but slow growth in length. The youngest flabellules are found at the apex of the rhachis, which in *R. phoenix* is either longer or shorter than the capitulum. When the rhachis is longer, the apex of the capitulum is conical, owing to the gradual diminution in size of the successive flabellules. When on the other hand the rhachis is shorter, the capitulum terminates in an apical hollow, at the bottom of which are seen the youngest flabellules. This is sometimes the case in *R. phoenix*, but nearly always in *R. oblongus* — at least in fresh or pickled plants; in dried herbarium specimens the cavity escapes notice, having become closed as the result of pressure in drying.

What the limit of the apical growth of the rhachis is we do not know. We give, under *R. phoenix* f. *longifolius*, a description of a unique specimen of twice the ordinary size. The total length of the stipes is 15 cm. and the flabellules are nearly 5 cm. long. It is quite easy to explain the existence of such an abnormally large plant of *R. phoenix* by means of the theory of continued apical growth, young flabellules being continually added above, while the older ones drop off below. This continued growth of the rhachis forms one of the fundamental differences between this genus and *Penicillus*.

The flabellules of *Rhipocephalus* arise as branches of the main filaments within the stipes. Each such branch passes out through the cortex and soon divides dichotomously, first at quite short, then at greater or vastly increased distances, but always in one and the same plane, diminishing in diameter at each dichotomy. The component filaments are parallel, being either laterally coherent (*R. phoenix*), or approximated but free (*R. oblongus*). Their external pellicle is calcified and porous.

The geographical distribution of the genus ranges from Florida to Guadeloupe. The plants appear to grow in colonies on coral sand in calm and shallow waters.

Systematic.

The two species which compose this genus are easily distinguished from one another, by the composition of the flabellules, the filaments of which are narrow and laterally coherent in *R. phoenix*, and free from one another and 2—3 times as thick in *R. oblongus*.

The genus itself broadly resembles *Penicillus* in size and general habit, but is distinguished from it by the possession of flabellules in contrast with the fascicles which compose the capitulum of *Penicillus*. The flabellule of *Rhipocephalus* is a branch-system with the dichotomies arranged all in one plane and is fundamentally distinct from the fascicle of *Penicillus*, which has its dichotomies arranged in alternating planes. Another point of difference is that in *Rhipocephalus* the rhachis possesses the power of continued apical growth, whereas in *Penicillus* the apical growth is limited.

These differences appear to us to be amply sufficient to indicate that these two genera,

though passingly alike, are not in reality closely allied. *Rhipocephalus* is more nearly allied with the simple species of *Udotea*, namely *U. javensis* and *U. glaucescens*, being as it were a stalked community of those species; in the same way as *Penicillus* is a stalked community of *Espera* (see pp. 72, 89). *Rhipocephalus* and *Penicillus* do however find an intermediate in the curious dimorphic *Tydemania expeditionis*, which produces flabellules near its base and glomeruli above, composed of filaments dichotomously branched in alternating planes (see p. 66).

Rhipocephalus Kützing

Phyc. Gen. 1843. p. 311.

Nesaea et *Nesea* auctorum pro parte.
Penicillus auctorum pro parte.
Rhipocephalus J. G. Agardh Till Alg. Syst. V. 1887. p. 64.
Rhipocephalus De Toni Syll. Alg. I. 1889. p. 503.
Rhipocephalus Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 393.
Rhipocephalus Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil. 1890. p. 142; also Nachträge 1910. p. 129.

Root-mass fibrous, long, branched, sometimes matted into a dense bulb.

Stipes erect, terete, encrusted externally, hollow or laxly fibrous within, composed of numerous, longitudinal, interwoven filaments, dichotomously branched, and bearing dichotomously branched lateral appendages, the obtuse or truncate peripheral endings of which are approximated together to form a cortex, which becomes thickly calcified, and appears very minutely porose under the microscope.

Capitulum green to glaucous or bleached, globose or oblong to cylindrico-conic, composed of numerous normally distinct and imbricate, erect or ascending (rarely spreading), flat, cuneate flabellules, often arranged in pseudo-verticils; each flabellule emerging from the rhachis as a single filament which divides dichotomously 4—6 or even more times in one plane.

Filaments of the flabellule parallel, contiguous and cemented together, or approximated and free, constricted at the base of each branch, covered with a porose calcareous pellicle.

Key to the Species.

Filaments of flabellules laterally coherent throughout their length, 60—90 μ above in diameter, 200—300 μ at base . . . . . 1. *R. phoenix*.
Filaments of flabellules free throughout their length, 160—200 μ above in diameter, 200—350 μ at base; stipes usually twice as long as in *R. phoenix*. 2. *R. oblongus*.

1. *Rhipocephalus phoenix* Kützing

Phycologia generalis 1843. p. 311.
Corallina Phoenix Ellis et Solander Nat. Hist. Zooph. 1786. p. 126. tab. 25, figs. 2, 3.
Corallina Phoenix Gmelin Linn. Syst. Nat. vol. I, part VI. 1790. p. 3843.
Corallina Phoenix Bosc Hist. Nat. des Vers (Suites à Buffon) vol. III. 18mo Paris (Déterville) 1802. p. 72.
Nesæa Phoenix Lamouroux Mém. Class. Polyp. Corall. in Nouv. Bull. Sci. Soc. Philomat. Paris III. 1812. p. 185.

Penicillus Phoenix Lamarck Sur les Polyp. empât. in Ann. Mus. Nat. Hist. Paris tom. 20. 1813 p. 293.
Nesea Phoenix Lamouroux Hist. Polyp. Corallig. Flex. 1816. p. 256.
? *Nesea eriophora* Lamouroux op. cit. p. 257.
Penicillus Phoenix [Pinceau flabelle] Lamarck Anim. sans vert. tom. II. 1816. p. 341.
Corallina phoenix Cuvier Règne Animal. IV. 1817. p. 77.
Nesea Phoenix Lamouroux Expos. Meth. 1821. p. 22, tab. 25, figs. 2, 3.
Nesea phoenix Deslongchamps in Encyclop. Méth. Zoophyt. 1824—5. p. 568.
Nesea eriophora Deslongchamps in op. cit. p. 569.
Nesea phoenix Blainville in Dict. Sci. Nat. XXXIV. 1825. p. 492.
Nesea eriophora Blainville in op. cit. p. 493.
Penicillus Phoenix Blainville in op. cit. XLI. 1826. p. 50.
Penicillus Phoenix Blainville Man. d'Actinolog. 1834. p. 553.
? *Penicillus eriophora* Blainville op. cit. p. 553.
Penicillus Phoenix Lamarck Anim. sans vert. Ed. II. tom. II. 1836. p. 525.
Penicillus Phoenix Decaisne in Ann. Sci. Nat. 2de sér. tom. XVIII. 1842. p. 110.
? *Corallocephalus eriophorus* Kützing Species Algarum 1849. p. 506.
Rhipocephalus Phoenix Kutzing op. cit. p. 506.
Nesea phoenix Duchassaing Animaux Radiaires des Antilles. Paris 1850. p. 28.
Rhipocephalus Phoenix Kützing Tab. Phyc. vol. VIII. 1858. p. 12. tab. 27, fig. II.
Penicillus phoenix Harvey Nereis Bor.-Amer. vol. III. 1858. p. 46. tab. XLIII. c.
Udotea plumula Crouan in Schramm et Mazé Essai de Class. Alg. de la Guadeloupe 1865. p. ?.
Udotea Phoenix Crouan in Mazé et Schramm Essai de Class. Alg. de la Guadeloupe. Ed. II. 1870—1877. p. 87.
Udotea Phoenix var. *elatior* Crouan, in Mazé et Schramm loc. cit.
Penicillus Phoenix Farlow in Proc. Amer. Acad. X. 1875. p. 378; also in U. S. Fish Comm. Report, III. 1876. p. 712.
? *Nesea eriophora* Lamour. in J. G. Agardh Till Alg. Syst. V. 1887. p. 63.
Rhipocephalus phoenix J. G. Agardh op. cit. p. 65.
Rhipocephalus phoenix Murray in Journ. of Bot. XXVII. 1889. p. 238.
Rhipocephalus phoenix var. *elatior* Murray loc. cit.
Rhipocephalus phoenix De Toni Syll. Alg. I. 1889 p. 504.
Rhipocephalus phoenix A. & E. S. Gepp in Journ. of Botany. XLIII. 1905 p. 4.
Rhipocephalus phoenix Howe in Journ. New York Bot. Garden. IX. 1908. p. 125. fig. 18.
Rhipocephalus phoenix Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 393.

Hab. ATLANTIC. Banc de Bahama (sub nom. "*Nesea Phoenix*") *Herb. Lamouroux*! — Bahamas, Herb. Lamouroux in *Herb. Mus. Paris*! — Bahama Bank, *F. M. Rayner*! — Bahamas, Bemini Harbour, in 1—6 dm. of water at low tide, *M. A. Howe* n° 3239! — Bahama, Quarantine Cay, *Herb. Collins*! — Florida, *Rugel*! — Florida, Boca Chica Key, *Southwick* in Herb. Collins! — Florida, Key West, *Harvey*! — Key West, *M. A. Howe* in Phyc. Bor. Amer. n° 1030! — Key West, on sandy bottom in 6 dm. of water at low tide, *Howe* n° 1612! — Guadeloupe, *Mazé* nos 848, 868, 1521, 1ere ser. n° 176, n° 24 (sub nom. "*Udotea Phoenix* var. *elatior*")! — Antilles, *Herb. Decaisne*! — Without locality, *Herb. Chauvin*! — Without locality, Herb. Samuel Dale (1659—1739) in *Herb. Mus. Brit.*!

Stipes usually short 1—2.5 cm. in length (in one extraordinary specimen 15 cm. long), 2—5 mm. in diameter, compressed or terete, with smooth calcified surface very minutely pseudoporose under microscope.

Capitulum very variable, from globose to cylindrico-conic, reaching a length of 10 cm. and a width of 4 cm., usually about 3—5 cm. long and 1.5—2.5 cm. broad; formed of numerous, flat, cuneate, truncate or obtuse, normally ascending, unilamellate, shortly pedicellate flabellules,

0.5—2 cm. long (4.5—5.0 cm. long in forma *longifolius*), normally arranged in closely imbricating whorls or plates, the constituent flabellules being either laterally coherent into collars which completely encircle the stipes, or into less complete collars or plates, or becoming completely detached from one another.

Filaments of flabellules 60—90 μ in diameter above, 200—300 μ at base, six or more times dichotomous, and laterally cohering in one plane, calcified, rigid, here and there constricted along the internodes (rarely beaded).

Filaments of stipes bearing lateral appendages 5—7 times dichotomously divided and terminated by very narrow, more or less dactyline, obtuse or truncate apices. [Figs. 183—188].

forma *typicus* A. & E. S. Gepp l. c.

Hab. ATLANTIC. West Indies, Bahamas (figured by Ellis and Solander (loc. cit.) sub nom. *Corallina Phoenix*). — Banc de Bahama, *Herb. Lamouroux*! and *Herb. Mus. Paris*!

Flabellules about 15 mm. long, about 10 mm. wide, forming an ovoid capitulum (about 5 cm. long by 3 cm. wide), which for three-quarters of its length is penetrated by the stipes (rhachis). [Fig. 183].

forma *brevifolius* A. & E. S. Gepp l. c.

Hab. ATLANTIC. Bahamas, Bemini Harbour, in 1—6 dm. of water at low tide, *M. A. Howe*, n° 3239! — Guadeloupe, *Mazé* n° 24, 1ère sér. in Herb. Mus. Brit.!

Flabellules 5—10 mm. long, about as wide as long, usually laterally conjoined into ascending, sheathing, densely imbricated collars or verticils arranged in a neat capitulum, which is often cylindric or elongato-conical; stipes (rhachis) percurrent almost to the apex of the capitulum. Filaments of flabellules 90 to 70 μ in diam. above, up to 300 μ at the basal pedicel. [Figs. 184—186].

forma *longifolius* A. & E. S. Gepp l. c.

Hab. ATLANTIC. Florida, Key West on sandy bottom in 6 dm. of water at low tide, *Howe* n° 1612!

Flabellules 20 mm. or more long, 4—5 times longer than broad, cuneato-linear (elongate, up to 50 mm. long and 6—8 mm. wide, in one abnormal specimen which has a stipes 15 cm. long), truncate or obtuse and entire at apex or sometimes laciniate, usually ascending and imbricate, in large plants not coherent into collars. Stipes (rhachis) penetrating to $^1/_2$—$^3/_4$ of the length of the capitulum (depending upon the length of the flabellules). Filaments of flabellules mostly 60 μ (rarely 55 μ) in diam. above, increasing to 200—220 μ at the basal pedicel. [Figs. 187, 188].

Rhipocephalus phoenix is characterised by the form of its capitulum. This consists of a central rhachis from which arises normally a close series of ascending imbricating verticillate collars or plates, each composed of one or more flabellules. Each flabellule emerges from the rhachis as a short simple filament which, dividing dichotomously, first at short intervals (generally four close to base), then at greater or vastly increased distances, but always in one and the same

plane, forms the fan like flabellule. The branching filament, of which a flabellule is composed, tapers from the monosiphonous base to the apices — visibly at first, but afterwards very gradually and imperceptibly. As a consequence of this the ultimate ramuli are distinctly thinner in f. *longifolius* than in f. *brevifolius*. The filaments composing the flabellule have a porous calcareous sheath and are laterally coherent. Further the flabellules cohere laterally with their neighbours of the same whorl, and so form wide plates or complete collars which encircle the rhachis, but these lateral cohesions of flabellules are liable to become broken by wear and tear in older plants. It should be added that the successive dichotomies in the flabellule are so neatly arranged at first that, in f. *brevifolius* at least, they tend to lie in concentric zones (fig. 185).

The capitulum of *R. phoenix* is however very variable in its external appearance, namely in its shape, in the length of the flabellules and in their degree of lateral coherence with one another. These differences unfortunately do not afford sufficiently constant data for a satisfactory grouping of these varying plants. Nevertheless, for the sake of convenience three principal forms may be singled out for definition, as shown above. F. *brevifolius* (fig. 184) is the most clearly marked of these with its long regular subcylindric capitulum of closely imbricating short green collars. F. *longifolius* (fig. 187) is also fairly definite with its shorter obovate capitulum composed of irregularly imbricating separated plates or flabellules, which are 2—4 times as long as those of f. *brevifolius*, and consist of filaments with narrower diameter for the greater part of their length. Intermediate between these two is f. *typicus*.

F. *typicus*, the oldest representative of the species, was figured by Ellis and Solander loc. cit. as *Corallina phoenix*, the original plant of which is lost (our fig. 183 is a copy of their figure). Lamouroux copied Ellis and Solander's figures in his Expos. Méth. pl. 25, figs. 2, 3. Through the kindness of Prof. Lignier of Caen, we have been able to examine the plants referred to *Nesea phoenix* in Lamouroux's herbarium. They are labelled in his MS. as coming from "Banc de Bahama". One of his specimens is in the Paris Herbarium, and bears two labels, one written by Lamouroux, the other by Decaisne ("*Penicillus Phoenix* — Bahama, ex herb. Lamouroux"; with the pencilled addition "*Rhipocephalus*"). These appear to be the oldest specimens known, except that of Samuel Dale.

An attempt was made in Mazé & Schramm's Algues de la Guadeloupe Ed. II. 1870—77 p. 87 to divide this species, called by them *Udotea phoenix*, by splitting off a var. *elatior* Crouan (without description). Under the latter is given as a synonym *Udotea plumula* Crouan, published in Schramm and Mazé's first edition (1865) of the book, a very rare volume which we have never been able to meet with. Mazé issued examples of this variety (*Udotea phoenix* var. *elatior* Crn.) under n°. 24, 1ere sér., in his exsiccatae. There are in the British Museum and in the Kew Herbarium specimens of this which are entirely different from one another. The British Museum specimen is 16 cm. long including the rhizoids, and has a tapering capitulum 8 cm. long composed of short flabellules; it is an excellent example of our f. *brevifolius*. The Kew plants on the other hand are very short, not exceeding 4.5 cm. high, with lax capitulum composed of flabellules up to 2 cm. long, and must be referred to our f. *longifolius*. We are therefore unable to understand what were the characteristics of Crouan's var. *elatior*.

The best preserved specimens of *R. phoenix* which we have seen were collected by

Dr. M. A. Howe, some dried, some in formalin, the latter answering well to their local name of "Noah's Ark Trees". As was fitting, we selected from these the types of our f. *brevifolius* (fig. 184) and f. *longifolius* (fig. 187).

The most remarkable specimen of *R. phoenix* that we have seen was collected in Florida by Rugel and is in the British Museum (fig. 188). It is characterised by the great length of its stipes (15 cm.) and of its comal flabellules (4.8 cm. long). Though nearly twice as long as any other specimens known to us, it is nothing but an overgrown lanky example of our f. *longifolius*, differing only in size and laxity, the result of long-continued apical growth under favourable conditions. The tapering filaments of the flabellule diminish to about 55 μ towards their apices. Further remarks on this plant were made in Journal of Botany XLIII 1905, p. 4.

The flabellular filaments of *R. phoenix* are so slender that to this species we are inclined (see p. 85) to refer Lamouroux's *Nesea eriophora* (Hist. Polyp. Corall. Flex. 1816. p. 257), described as having filaments "déliés comme des filamens de laine". There is in Herb. Mus. Brit. a specimen of *R. phoenix* (Herb. Samuel Dale) in which the flabellular filaments are bleached white, and by rough usage have become partly decalcified and dishevelled, giving the appearance of soft fine wool answering to the description of *N. eriophora*. Lamouroux at that time (1816) had never seen an actual specimen of *R. phoenix*, as is shown by the asterisk placed before *Nesea Phoenix* (op. cit. p. 256). He had only seen Ellis and Solander's figure.

The present species exhibits an interesting affinity with two other genera — *Udotea* and *Tydemania* — in the fact of possessing calcified monostromatic flabella. In *U. javensis* (fig. 36) and in *U. glaucescens*, when young, the flabellum is solitary and terminal on the monosiphonous stipes. In *Tydemania expeditionis* (fig. 154) the flabella arise in single or double pairs from one or more basal nodes on the monosiphonous main axis. In *Rhipocephalus phoenix* the flabellules are arranged in pseudo-verticils around the rhachis, forming a capitulum; they are terminal on branches from the filaments of the compound stipes.

The geographical distribution of *R. phoenix* is confined to the West Indies.

2. *Rhipocephalus oblongus* Kützing

Species Algarum 1849. p. 506.

Syn. *Penicillus oblongus* Decaisne Mém. sur les Corallines in Ann. Sci. Nat. 2de sér. tom. XVIII. 1842. p. 109.
Rhipocephalus oblongus J. G. Agardh Till Alg. Syst. V. 1887. p. 62, 65.
Rhipocephalus oblongus De Toni Sylloge Algarum I. 1889. p. 504.

Hab. Atlantic. Bahama, (sub "*Penicillus Lamourouxii* Dne" in Decaisne's hand-writing), *Herb. Mus. Paris*! — Banc de Bahama, (sub "*Nesea penicillus* var.") *Herb. Chauvin*! and *Herb. Lamouroux*! — Bahamas, Bemini Harbour, in 3—8 dm. of water, low tide, with *R. Phoenix* &c. *Howe*, n° 3235! — Bahamas, Berry Island, Lignum Vitae Cay, *Howe* n° 3647!

Stipes penetrating to about $^3/_4$ of the capitulum (rarely excurrent at apex), variable in length, generally 4—6.5 cm., about 6 mm. wide, sometimes terete, with more or less smooth, calcified surface, minutely pseudoporose under microscope.

Capitulum green, sometimes bleached, up to 5.5 cm. long, and 1—3 cm. broad, having

a cup-shaped depression at the top, at the base of which lie the young apical flabellules, subcruciately disposed (fig. 191 *a*).

Flabellules concate, 7—15 mm. long, arranged in ascending imbricate pseudoverticils. Filaments of the flabellules with a diameter of 160—200 μ above, 200—350 μ at base, thick-walled, calcified thinly towards apex, branching dichotomously in one plane, digitate, subparallel, free, the 2—3 basal tiers very short, the upper ones much longer, with occasional constrictions on the internodes.

Filaments of stipes bearing lateral appendages 5—7 times dichotomously divided and terminated by narrow, more or less dactyline obtuse apices. (Figs. 189—192).

This species is not by any means so well-known as *R. phoenix* and is not commonly found in herbaria, at least under its own name. Its main characteristics are as follows. The flabellules arise in pseudo-verticils around the top of the stipes (rhachis), curve upwards and are imbricated. Each flabellule emerges from the rhachis as a short simple filament, which divides dichotomously, first at very short, then at much longer distances, but always in one and the same plane; the resulting branches are arranged digitately side by side, but they are not closely contiguous nor cemented together as in *R. phoenix*. They may perhaps occasionally be partially cemented together, as DECAISNE's diagnosis implies, for instance, at the base of the flabellule; but we have never seen them otherwise than entirely free. The ultimate ramuli of the flabellule-filament are usually twice as thick as those of *R. phoenix*, being about 170—200 μ in diameter.

At the top of the capitulum is a cup-shaped hollow (fig. 191) formed by the upper whorls of curvately ascending flabellules. At the bottom of this hollow is visible the apex of the stipes (rhachis) bearing the youngest flabellules, which have almost the appearance of being cruciately arranged (fig. 191 *a*). The apical cup-shaped depression was first noticed by Dr. M. A. HOWE and is clearly evident in the pickled material presented by him to the British Museum. In specimens that have been dried by pressure the cavity is closed by the compression and escapes notice. It is only partially, if at all, recoverable when the plant is soaked.

R. oblongus may be briefly described as distinguished from *R. phoenix* by the hollowed apical cavity in its capitulum, by the flabellules composed of free filaments (not laterally coherent with one another), and by the diameter of the filaments which is twice as large as in *R. phoenix*.

Curiously enough, *R. oblongus* is sometimes liable to be mistaken for *Penicillus capitatus*. In old and battered specimens of *R. oblongus* the filaments of the different flabellules are apt to become so tangled together that the flabellules become unrecognisable; if then the apical cavity has become obscured, such specimens are likely to be referred to *P. capitatus* by reason of the diameter of their filaments. Their true character may however be ascertained by an examination of the apex. On opening up the cavity it is generally possible to find the digitate apical flabellules which characterise *R. oblongus*. Further, the two or three lowest joints of *R. oblongus* are more or less short and of equal length, while those of *P. capitatus* are about twice as long, of irregular lengths, and often exhibit an occasional bead-like constriction; moreover the successive dichotomies are in alternate planes.

In his original diagnosis of *Penicillus oblongus* (loc. cit.) DECAISNE says "Hab. in Antillis (Bahama). (Herb. Mus. Par.)". Unfortunately there does not appear to be any specimen in the Paris Herbarium bearing the name of *P. oblongus*. There is however a plant which exactly answers to DECAISNE's diagnosis: but to it has been attached a label in DECAISNE's own MS. which says: "*Penicillus Lamourouxii* Dne. Bahama". This specimen (fig. 189), as has been shown under *P. Lamourouxii* (p. 80), is *not that* species. It is in fact without doubt, we think, DECAISNE's actual type of *P. oblongus*, but with a wrong label attached to it. It bears out DECAISNE's diagnosis in having the comal filaments ("articuli") flabellately arranged as in *R. phoenix*, and thicker than in that species, "nec in lamellis arcte connati"; the "articuli" are indeed *entirely* free from one another (fig. 190) and not "subliberi" as stated by DECAISNE. We feel absolutely justified in accepting this plant as DECAISNE's type.

Having only a dried and pressed specimen, DECAISNE naturally overlooked the characteristic apical hollow, which is nevertheless present in it.

Single specimens of this species were found by us in Herb. Lamouroux and Herb. Chauvin under the name "*Nesea Penicillus* var.", both from "Banc de Bahama" but without any collector's name. They are so much alike, that they were probably gathered at the same time.

The geographical distribution of *R. oblongus*, as known at present, is confined to the Bahama Islands.

13. Udotea Lamouroux.

(Figs. 1—28, 36—68).

Historical.

The earliest record of a plant of this genus is in SLOANE's Natural History of Jamaica, 1707. vol. I. p. 62, where *Udotea flabellum* is confused with *Padina Pavonia*, both these plants being included under the following description: "XXXII. *Fucus maritimus gallo pavonis pennas* "*referens*, C. B. Prod. p. 155. Cat. p. 5. This grows sticking to the Stones in the bottom of "the Sea, whence it is thrown on Shore in several places about Port Royal; and of it there is "a variety, with thicker and whiter Leaves, which is nothing but an incrustation of a Coralline "white matter over it." The variety here mentioned is *U. flabellum* as is shown by an examination of the original plants in the Sloane Herbarium, preserved in the British Museum.

The next reference of interest is to *U. conglutinata* and *U. flabellum*. Ellis & Solander give excellent figures and descriptions of these plants under the names *Corallina conglutinata* and *C. Flabellum* in their "Natural History of Zoophytes", 1786, pp. 124, 125, tab. 24, 25, fig. 7.

A few years later ESPER (Fortsetzung der Pflanzenthiere, II. Theil, 1798—1806) published two coloured plates (Tab. VIII & IX) labelled „*Corallina pavonia*" and "*Corallina pavonia* variet.", but published them without explanation. It has not been possible to find any account of these plates in the subsequent parts of the work, edited after ESPER's death by Prof. HAMMER of Strasburg. ESPER's Tab. VIII contains a figure which is an unmistakeable, though not a good, representation of *U. flabellum*, although to this plate LAMOUROUX himself (Hist. Polyp. coralligènes p. 312) takes exception, saying that the plant figured is so much divided

that it is an unnatural representation of this species. The divisions of the thallus are however such as may be found quite commonly in specimens of *U. flabellum*. Esper's other plate (Tab. IX) is a coloured reproduction of Ellis and Solander's Tab. 24. *U. flabellum* was generally regarded by early authors as an animal, and even in later times was placed with *Halimeda*, *Penicillus* and other encrusted algae in a subdivision of the animal kingdom.

In 1812 Lamouroux founded the genus *Udotea* (Mém. class. Polyp. coralligenes in Nouv. Bull. d. Sci. par la Soc. Phil. de Paris tom. III. 1812. p. 186), on *Corallina Flabellum* Ellis (= *U. flabellum*) and placed it among the Corallineae, a family of "Polypiers coralligènes non entièrement pierreux".

The following year Lamouroux published the third part of his paper entitled "Essai "sur les Genres de la Famille des Thalassiophytes non articulées" (Annales du Muséum d'Histoire Naturelle, Paris. tom. XX. 1813 pp. 267—292), in which he shortly describes his new genus *Flabellaria*, placing in it, as the only species, the *Conferva flabelliformis* of Desfontains under the name of *Flabellaria Desfontainii*. And of course he describes it as a plant, that is, he includes it among the true vegetable seaweeds.

Now at this time the two writers Lamouroux and Lamarck were publishing papers on the same groups of marine organisms, and the similarity of the authors' names and still more of the abbrevations of their names, is apt to be misleading; especially as they chance to have invented the very same generic name (*Flabellaria*) at the same time to denote certain species (*F. Desfontainii* of Lamouroux, as just mentioned above, and *F. conglutinata* and *F. pavonia* of Lamarck) which Decaisne thirty years later united generically under *Udotea*. Curiously enough, the very next paper to Lamouroux's is by Lamarck and is entitled "Sur les Polypiers empâtés" (Annales du Muséum vol. XX. 1813, pp. 294—312); and in it he too describes a new genus, *Flabellaria*, (l. c. p. 299) which he divides into two sections, one containing organisms with "Articulations réunies", and the other with "Articulations distinctes". In the first section he places two species, *Corallina conglutinata* Ell. & Sol. (see *U. conglutinata* p. 114) as *Flabellaria conglutinata* Lamarck, and *Corallina flabellum* Ell. & Sol., (which, as shown above, had already been made the type of Lamouroux's genus *Udotea*) as *Flabellaria pavonia* Lamarck pro parte. (The second section of *Flabellaria* is composed of species now known as *Halimeda*). No mention is made by Lamarck of Lamouroux's use of the name *Flabellaria* in the paper immediately preceding his own; and one is therefore justified in supposing that both Lamouroux and Lamarck simultaneously invented the same name, *Flabellaria*, one to denote a new genus of plants, the other a new genus of animals; and both, strangely enough, were founded on species which since 1842 have been included in *Udotea* at the instance of Decaisne. [For reasons stated on p. 48 we regard Lamouroux's *Flabellaria* as sufficiently distinct to be maintained as a genus distinct from *Udotea*]. Lamarck moreover was apparently ignorant of Lamouroux's creation of the name *Udotea* in the previous year, to designate *Corallina Flabellum* of Ellis and Solander.

To return to Lamouroux; in 1816 he published his "Histoire des Polypiers coralligènes flexibles, vulgairement nommés zoophytes", and on p. 310 he gives a fuller description of his genus *Udotea* than he had done four years earlier, and quotes as a synonym of his *U. fla-*

bellata the *Flabellaria Pavonia* of LAMARCK. LAMOUROUX also adds as a second species, though with some hesitation, *Udotea conglutinata* (*Flabellaria conglutinata* Lamarck). He regards them both as animal structures, but takes exception to the view held by LAMARCK as to their inclusion among the "Polypiers empâtés" and says that all other zoologists agree in regarding them as Corallines.

In the years that followed these publications, the group of Corallines, in which was included the genus *Udotea*, was mostly regarded as either belonging to the animal kingdom or else was placed among the algae with reservation, as being unconnected with any other family of algae. It remained for DECAISNE in his "Mémoire sur les Corallines" in Ann. Sci. Nat. Bot. 2me série, tom. XVIII. 1842. pp. 96—128, and also for CHAUVIN in his Recherches... Caen, 1842 pp. 124—128 independently to lay down clearly and finally the fact that the Corallines are plants. DECAISNE divides them into Zoosporeae (= Siphoneae), Aplosporeae (= *Galaxaura*, *Liagora* and *Actinotrichia*), and Choristosporeae (= Corallinaceae). For *Udotea* he describes four species, *U. flabellata* Lamx., *U. palmetta* n. sp., *U. cyathiformis* n. sp., and *U. Desfontainii* (the *Flabellaria Desfontainii* of LAMOUROUX). DECAISNE gives an account of the structure of the thallus of *Udotea*, and in his remarks alludes to *U. flabellum* under the name of *U. pavonia*, without however giving the name of *U. pavonia* as a synonym for *U. flabellum*. The genus therefore contained in 1842 only four species.

We must now return to CHAUVIN. It is clear that his paper was published after that of DECAISNE, for CHAUVIN in a footnote to his Essai d'une Répartition des Polypiers Calcifères de Lamouroux dans la Classe des Algues (Recherches .... Caen, 1842 p. 124) says: — "Lorsque le Mémoire de M. DECAISNE sur les Corallines ou Polypiers calcifères a été rendu "public, le nôtre était terminé; il a été livré a l'impression tel qu'il avait été composé d'abord".

CHAUVIN divided the Polypiers calcifères into two groups only — Zoosporeae and Choristosporeae, placing in the former group LAMOUROUX's *Flabellaria* reformed to include the following four species: — 1. *F. Desfontainii* Lamx. (= *Codium membranaceum* Ag.); 2. *F. fimbriata* Chauv. (= *Codium flabelliforme* Ag.); 3. *F. conglutinata* Chauv. (= *Udotea conglutinata* Lamx.); 4. *F. incrustata* Chauv. (= *Udotea flabellum* Howe). His first two species are of course regarded as synonymous nowadays.

The next connected account of *Udotea* is given by J. G. AGARDH in his Till Alg. Syst. V. 1887 p. 67. This author alludes to the confusion over the two genera of *Flabellaria* and to other historical details, and gives a description of the structure of various species. He divides the genus into four subdivisions: I. Palmettae, II. Incrustatae, III. Fibuliferae, IV. Corticatae. Among these subdivisions he distributes seven species, one of them, *U. peltata*, being new to science. Under "Species mihi nullo specimine cognitae", he adds 6 names with references and, in four cases, the locality. This summary of *Udotea* served as the basis of DE TONI's treatment of the genus in his Sylloge Algarum (vol. I. 1889 pp. 505—512) where fifteen species are enumerated, of which six are either doubtful, little known or excluded from the genus.

Morphological.

External characters. The thallus of *Udotea* consists of stipes and frond with or without a root-mass. As a rule, a single stipes arises from the root-mass and bears a single

frond. The frond is usually simple and flabelliform, infundibuliform, sometimes proliferous or even repeatedly proliferous, and the external form is subject to variation in most of the species. Also the frond is often concentrically zoned, and sometimes longitudinally striate or rugose, but both these characters are far from stable. The colour of dried specimens may be any shade from deep green to ashy-white. The margin, or even the frond itself, may be more or less deeply lacerate, but this is probably often the result of external influences, such as wave-action, etc.

Calcification. All the species of *Udotea*, as here defined, are calcified, some species much more than others, e. g. *U. flabellum* is thickly encrusted, while *U. indica* is thinly coated. Broadly speaking the species may be divided into two groups in regard to calcification: 1) those in which the filaments of the frond remain obvious, as in *U. orientalis* (fig. 4), *U. glaucescens* (fig. 5), etc., where they have the appearance of being separately coated with a thin layer of calcium carbonate; 2) those in which the main filaments become entirely concealed, as in *U. argentea*, *U. flabellum*, etc., where the filaments and their lateral appendages become involved in one common mass of incrustation.

In the first group, the calcareous sheath of the filaments is seen to be porose, just as in *Penicillus* (compare fig. 182). The pores are variable in size and distribution even in the same plant. What is the meaning of these pores? They can scarcely be regarded as windows for the more efficient illumination of the interior of the filament, since the calcareous sheath is already so thin and translucent as to offer little hindrance to the passage of light. In all probability their distribution corresponds with that of the green chromatophores inside the filaments, and they themselves mark the spots where bubbles of oxygen were evolved during the photo-synthetic process of the plant. Presumably the deposition of calcium carbonate would be effected at the time of photosynthesis only and naturally could not occur at those points where bubbles of gas were clinging to the sides of the filaments. It will doubtless be objected that the chromatophores, owing to the streaming movement of the protoplasm, would not remain stationary long enough to lay down even the foundations of the pores. But we would point out that at and near the growing apices of the filaments the protoplasm is usually densely congested, namely, in the very region where the thin porose calcareous sheath first begins to be visible. Thus there is a stasis of the protoplasmic circulation at the young ends of the filaments, which appears to be sufficiently prolonged for the mapping out of the young pores. The pores, thus initiated, doubtless become permanent, since they would naturally provide the readiest outlets for the oxygen-bubbles. In these plants of the first group the starch is found stored, not in the well-illuminated main filaments of the frond, but in those of the thickly encrusted (and hence dark) stipes.

In the second group, on the other hand, abundant starch is found stored in the main filaments of the frond (as in *U. flabellum*), indicating the darkness of the interior of the frond due to the thick encrustation. The question arises how in this case is sufficient illumination provided to effect the formation of this large store of starch. The answer to this question is obvious to anyone when the calcified surface is submitted to examination under a low power of the microscope (40 diameters). The surface is seen to be pitted with innumerable "pores" which

vary in size according to the species (compare the stipes-cortex of *Penicillus*, figs. 163, 168, 175). They are very minute in *U. flabellum*, and so large in *U. argentea* var. *spumosa* as to be visible under a pocket lens. These "pores" are the uncalcified apices of the simple or branched lateral appendages of the frond filaments; and these apices, being flush with the surface, form innumerable "windows" for the entrance of light. And these "windows", like the pores of *Penicillus*, *U. conglutinata*, &c., presumably escape calcification owing to the bubbles of oxygen which, evolved by the chromatophores lodged inside, cling to the outside of the "windows" (see p. 5).

Internal structure. The thallus of *Udotea* is composed of continuous non-septate filaments which, branching dichotomously and repeatedly, more or less in one plane, form a flabellate frond which may be monostromatic as in *U. javensis*, *U. glaucescens*, etc., or pluriseriate as in *U. conglutinata*, *U. flabellum* etc. The diameter of the filaments varies with the species from about 25 μ to 100 μ, and is a diagnostic character of some importance.

According to the structure of the filaments the genus may be divided into two groups [1]). In one the filaments are destitute of lateral appendages; in the other they bear lateral appendages which vary according to the species. In the first group the simplest structure is found in *U. javensis* (fig. 36) which has a persistently monosiphonous stipes, and a monostromatic frond. In *U. glaucescens* (figs. 3, 5) the frond remains monostromatic, but the stipes in mature plants becomes branched and corticated, and the base of the frond covered with fibulae. In *U. conglutinata* (fig. 44) and *U. orientalis* (figs. 1, 4) the frond is pluriseriate. *U. cyathiformis* (fig. 2) belongs to the same structural group, but has an infundibuliform frond, not a flabellum.

In the second group, which is characterised by its lateral appendages, the simplest form is *U. papillosa* (figs. 17, 37), with monostromatic frond composed of filaments studded on frond and back with papillae (fig. 20), and with a stipes monosiphonous in young stages. The other species all have a compound stipes. In *U. verticillosa* (fig. 16) the frond is monostromatic above, pluriseriate below; the upper filaments are closely beset on front and back with 2—4-furcate spinose appendages in pseudo-verticils (fig. 23 *a*). In *U. argentea* (figs. 57 and 15) the frond is distromatic above, pluriseriate below; and the filaments bear capitate lateral appendages arranged distichously (figs. 58 *a*, *b*, *c*). In *U. flabellum* (fig. 26) the filaments are pluriseriate, and the lateral branchlets are fewer in proportion and bear cymoid heads (fig. 27 *a*). In three species forming a section of the second group, the lateral appendages are produced only where they are functionally required, that is, on the exterior surface of those filaments of the pluriseriate frond which are situated superficially on the frond, and the lateral appendages are, as explained elsewhere, needed as "windows" (p. 5). These three species are *U. indica* (fig. 52) with short truncate appendages (figs. 13, 53), *U. palmetta* (figs. 10, 11) and *U. spinulosa* (figs. 55, 56 and 12) with acute, simple, or forked appendages. The same arrangement is also found in the lower (pluriseriate) part of the frond of *U. verticillosa* and *U. Wilsoni*.

Cortex. The cortical covering of the frond, as may be gathered from what has been

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1) For the decalcification of specimens the best medium is Perenyi's fluid (4 parts nitric acid 10%; 3 parts alcohol; 3 parts chromic acid 0.5%). After treatment with this fluid the structure becomes clearly visible.

said above, occurs only in certain species, and varies in character according to the shape of the lateral appendages. It is from the approximated or contiguous ends of the lateral appendages that the so-called cortex is formed. For instance, in *U. indica* fig. 53 and *U. argentea* var. *spuria* it is a simple monostromatic pseudo-parenchyma. In *U. flabellum* it is firmer and denser and composed of smaller elements. In *U. palmetta*, *U. spinulosa* and *U. verticillosa* the spines, emerging superficially from the two surfaces of the frond, form a loose furry cortical covering thereto. The deposition of calcium carbonate either strengthens on the one hand the cohesion of the component elements of the cortex or, on the other hand, helps to bind together the loose spinose lateral appendages into a more or less continuous mass.

Fusions. The filaments do not normally coalesce in the upper margin of the frond and lobes, in the manner characteristic of the central strand in the articulations of *Halimeda*. But in *U. argentea*, at the base of the marginal proliferations of the frond, we have occasionally noticed a distinct fusion of two filaments into one, which thereupon branches dichotomously in normal fashion. This however is apparently of rare occurrence and is always difficult to detect, being obscured by the presence of numerous lateral appendages. In other cases two or more filaments are found cohering together laterally, but not fusing, at the base of a proliferation. Whether perchance these junctions or cohesions may somehow be due to fortuitous injury of the apices of the filaments at an earlier period, we are unable to say. Be this as it may, we have in a few species commonly noticed that at the base of a proliferation, the outline of the previous margin of the frond is plainly indicated by a zone consisting of a deformed thickening of the filaments (for a length of 20—30 μ) and of their walls. And further, these thickened filaments end each in a blind apex, the new growth consisting of a single branch (not a dichotomy), which has emerged a little below the aforesaid apex. This shows clearly that there was for some reason a resting stage before the forming of the new proliferation. We have noticed that such a zone is sometimes marked in *U. verticillosa* by a thin fringe of short loose excurrent branches of the frond-filaments.

Stipes. The stipes, as shown above, is monosiphonous in the simplest species, *U. javensis* (fig. 36), and in small specimens of *U. papillosa* and *U. glaucescens*. In older plants of these two latter species, the stipes becomes polysiphonous: in *U. papillosa* by the production of rhizoids (fig. 37) which descend and form a covering of the original siphon: and in *U. glaucescens* by the production of branches (fig. 43) which become bound together and enveloped by a cortex composed of ramified lateral appendages, such as characterise the other species of *Udotea*. The stipes-structure of *U. orientalis* is well figured under the name *U. conglutinata* by Okamura (Icones of Japanese Algae I. 1908 tab. XLV figs. 9, 10). In the species which have a corticated frond, the lateral appendages of the stipes-filaments usually show a broad resemblance to those of the frond-filaments. The corticated stipes is simple in most of the species, but is very shortly branched at the apex in *U. glaucescens* and *U. Wilsoni* (fig. 66).

Root-mass. The root-mass consists of a loose felt-work, which is composed of a comparatively small number of fairly straight, thick filaments, bearing throughout their length numerous fascicles of repeatedly and furcately branched, tapering, slender, colourless root-hairs (fig. 9). These root-hairs become interlaced with each other and with the particles of

coral sand in which the plants grow, often forming a bulbous mass, as is seen in the figure of *U. flabellum* (Pl. III. fig. 26).

Cell-contents. For want of living material, we are only able to state that starch occurs in great abundance in the parts of the plant which are not exposed to light, namely in the rooting parts, and in thickly calcified stems and fronds, for instance in the frond-filaments of *U. flabellum*.

As to the distribution and character of the chromatophores, we are unable to offer any remarks (save in relation to the pores of the calcareous sheath p. 102).

Fruit. The sporangia of *Udotea* are unknown. So-called zoosporangia have been described and figured for *U. Desfontainii*, a species which we exclude from the genus *Udotea*, and describe under the name *Flabellaria petiolata* (p. 48). As stated under *Flabellaria*, these zoosporangia require confirmation. In *Udotea* proper the sporangia may be expected to occur at the apices of filaments at the margin or on the surface of the frond, as in *Avrainvillea* or *Halimeda*. We have been unable to find any trace of sporangia in *Udotea*, unless it be that the blind apices referred to above in the paragraph on Fusions (p. 104) represent the bases of old sporangiophores.

Geographical Distribution. *Udotea* flourishes principally within the tropical zone, but is not confined thereto, for *U. orientalis* extends to Natal and *U. javensis* occurs in Japan. Few details are available respecting the habit and manner of growth, but they appear to flourish on coral reefs and sand, even down to a depth of 100 meters below sea level. The geographical distribution of each species will be found under its own name.

Systematic.

Up to the time of publication of J. G. Agardh's account of *Udotea* in Till Alg. Syst. (loc. cit.), there was no attempt to classify the species of this genus according to groups. This author however divides the genus, as mentioned above, into four sections, founded on differences exhibited by the filaments of the frond as regards straightness, juxtaposition, manner and degree of calcification and the presence or absence of cortex and of connecting fibulae or lateral branchlets. The four sections are called Palmettae, Incrustatae, Fibuliferae, Corticatae. The first of these, Palmettae, contains three species — *U. glaucescens*, *U. palmetta* J. Ag. non Decaisne (= *U. orientalis* A. & E. S. Gepp), and *U. infundibulum* Suhr (= *U. cyathiformis* Decaisne); the second, Incrustatae, contains only *U. conglutinata*; Fibuliferae contains *U. Desfontainii* (= *Flabellaria petiolata* Trevis. see p. 48), and *U. peltata* J. Ag., which as we show on p. 45 must be regarded as representing a new genus, *Rhipiliopsis*. Corticatae contains only *U. flabellata*. Six other species are mentioned by name only, being unknown to the author. As Agardh omitted to borrow and examine Decaisne's type of *U. palmetta*, and evidently overlooked the original figure, he had only Decaisne's short and incomplete description to rely upon. Thus he fell into the error of regarding *U. suborbiculata* Sonder as synonymous with *U. Palmetta* Decaisne. The plant described by Agardh as *U. Palmetta*, must, we are convinced, be referred to our *U. orientalis*.

The species of *Udotea* are roughly separable into two groups, as Ellis and Solander

foreshadowed more than 120 years ago — (1) those in which the main filaments of the frond are plainly visible and are not concealed by a cortex; (2) those in which the main filaments are concealed by a cortex, or more or less obscured by the presence of papillae or more highly developed lateral appendages. Into the first division fall *U. javensis*, *U. glaucescens*, *U. conglutinata*, *U. cyathiformis*, *U. orientalis*, and *U. explanata*. In the second division are on the one hand *U. argentea*, *U. occidentalis* and *U. flabellata*, with pseudo-parenchymatous cortex and on the other hand *U. papillosa* with its subspecies *subpapillata*, *U. indica*, *U. palmetta*, *U. spinulosa*, *U. verticillosa* and *U. Wilsoni*, characterised by the presence of papillae or spines. These species constitute the genus, as delimited in the present paper.

The following morphological and geographical grouping might also be suggested:

A. Main filaments of frond destitute of papillae and of lateral appendages:

East Indies.	West Indies.
U. javensis.	
U. glaucescens.	
U. orientalis.	*U. conglutinata.*
U. explanata.	*U. cyathiformis.*

B. Main filaments papillose.

East Indies.

U. papillosa.

U. papillosa var. *subpapillata* (sp. prop.?).

C. Main filaments bearing lateral appendages:

a) Lateral appendages monostichous, secund.

East Indies.	West Indies.
U. indica.	
U. palmetta.	*U. spinulosa.*

b) Lateral appendages subverticillately or subdistichously arranged in upper part of frond:

West Indies.

U. verticillosa.

U. Wilsoni.

c) Lateral appendages produced on all sides of the main filaments (often appearing to be distichous), capitate, pedicellate; capitula simple or compound, never with acute apices:

East Indies.	West Indies.
U. argentea.	*U. occidentalis.*
U. flabellum.	*U. flabellum.*

From this distribution table it will be seen that only one of the species (*U. flabellum*) is common to the Eastern and Western hemispheres.

Another remarkable point which is of great systematic value is found in the relative position of the two constrictions above each dichotomy of the frond-filaments. These supra-dichotomial constrictions occur in all but three of the species (*U. flabellum*, *U. verticillosa* and *U. Wilsoni*), and are markedly *uneven* (see fig. 47) in the East Indian species with one

exception (*U. explanata*); and are *even*, that is, equidistant above the dichotomy (see fig. 45) in the West Indian species with the exception of *U. occidentalis*. What the cause of this difference is, and why it should be associated with such a difference of geographical distribution, we are unable to suggest. It appears to be a fundamental character, for it can be detected at an early stage in the budding dichotomy at the apex of a frond filament. There is thus a parallelism of species in the two regions, as the above table shews.

As regards the above exceptions, it should be noted that *U. occidentalis*, though a West Indian species, has *uneven* constrictions and is very closely allied to *U. argentea*, a species with a wide distribution extending from the Red Sea to Queensland. It seems possible that *U. occidentalis* may be an offshoot of *U. argentea*, modified by its West Indian environment. Its distribution is very limited.

As to *U. explanata*, an East Indian species with *even* constrictions (fig. 50), it has no actual parallel in the West Indies, unless it be the cup-shaped *U. cyathiformis*; and its presence in the East Indies is perplexing (see p. 121).

In *U. verticillosa* (fig. 23 *a*) and *U. Wilsoni* (fig. 67) the constrictions seem to be masked, or rather suppressed, as a consequence of the abundant production of lateral appendages. These originate so close to the apex of the filaments in these two species, as to interfere with or prevent the normal formation of the supra-dichotomial constrictions.

In *U. flabellum* there seems no reason why the supra-dichotomial constrictions should not exist, but the fact remains that they are absent in this species; and further, that this species is the only one which is common to the Old and New worlds (see pp. 106, 133). As stated on p. 133, we have failed to discover distinctions sufficient to separate the Eastern from the Western representatives of this species.

We have removed from the genus *Udotea* the following six species: *U. peltata* J. Ag. (= *Rhipiliopsis*, p. 45), *U. Desfontainii* Decaisne and *U. minima* Ernst which are placed in *Flabellaria* (p. 46), *U. amadelpha* Mont. which is an *Avrainvillea* (p. 42), *U. plumula* Crouan which is a synonym of *Rhipocephalus Phoenix* (p. 93), and *U. sordida* Mont. (= *Avrainvillea erecta*, p. 29).

Udotea Lamouroux

in Nouv. Bull. Sci. Soc. Philom. Paris III. 1812. p. 186.

Syn. *Flabellaria* Lamarck in Ann. Mus. Hist. Nat. XX. 1813. p. 294.
Udotea Decaisne in Ann. Sci. Nat. Bot. 2me sér. XVIII. 1842. p. 105 (pro parte).
Flabellaria Chauvin Recherches... 1842. p. 123 (pro parte).
Udotea J. G. Agardh Till Alg. Syst. V. 1887. p. 67 (pro parte).
Udotea De Toni Syll. Alg. I. 1889. p. 505 (pro parte).
Rhipidosiphon De Toni op. cit. p. 517.
Udotea Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil. 1890. p. 142, fig. 94 (pro parte)
Rhipidosiphon Wille in op. cit. p. 144.
Udotea Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 394.
Udotea Wille in Engler und Prantl natürl. Pflanzenfam. I. Teil, 2. Abteil. Nachträge 1910. p. 129 (pro parte).

Udotea Lamouroux.

Thallus calcified, composed of stipes and frond, with or without a root-mass.

Root-mass bulbous to elongate, composed of a few fairly straight, simple, thick filaments, bearing numerous fascicles of repeatedly forked, tapering root-hairs, loosely interwoven.

Stipes simple, occasionally divided above, either monosiphonous and bearing a few rhizoids, or standing upon the root-mass and composed of numerous branched filaments, which are laxly interwoven and bear lateral appendages; peripheral endings of the lateral appendages approximated together to form a cortex which is thickly calcified.

Frond either monostromatic and simply flabellate, or bi- to pluri-seriate and flabelliform or rarely infundibuliform, simple, lobed or proliferous, sometimes crispato-plicate, often concentrically zoned and longitudinally striate, deep-green to ashy-white, varying in thickness and calcification.

Filaments of frond branched dichotomously, occasionally trichotomously, all more or less parallel, or parallel in obliquely crossing layers; often bearing numerous papillae, or lateral appendages (or branchlets). Appendages unilateral, distichous, subverticillate, or irregularly distributed, occurring in the form of 1) acute or truncate papillae, 2) spines, sessile or stalked, simple or more or less furcate, with acute apices, or 3) stalks bearing simple or lobed or cymoidly branched capitula. Cortex, when present, composed of the approximated or contiguous apices of the lateral appendages, and encrusted with lime. Calcareous sheath of frond-filaments porose in those species which are destitute of lateral appendages.

The following characters are of prime importance in the discrimination of the species:

1. Structure of frond:
   a) Whether monostromatic or pluriseriate.
   b) Whether the filaments bear lateral appendages or not.
   c) The shape and arrangement of the lateral appendages.
   d) Whether the filaments are unevenly or evenly constricted above the dichotomies.
   e) The diameter of the filaments.
2. Structure of the stipes, whether monosiphonous or compound.

The following Key is based upon a consideration of the above characters.

Key to the species.

A. Main filaments visible in surface view, when magnified about 50 diameters. Frond often fissile.
   a. Frond monostromatic. Filaments parallel, laterally coherent.
      α. Filaments of frond without papillae.
         1. Plant small, about 1—2 cm. high. Stipes always monosiphonous. Filaments of frond 40—50 *μ* thick . . . 1. *U. javensis* (p. 110).
         2 Plant larger, up to 5 cm. high. Stipes compound, corticated. Filaments of frond 65—80 *μ* (or more) thick. 3. *U. glaucescens* (p. 113).

β. Filaments of frond bearing numerous, more or less obvious, distichous papillae.

1. Filaments 30—45 μ in diam.; beset with evident papillae from base to apex. Length of papillae equals diameter of filament . . . . . 2. *U. papillosa* (p. 111).

2. Filaments 30—55 μ in diam., fibuliferous at base of frond, bearing low, inconspicuous papillae above . . . subsp. *subpapillata* (p. 112).

b. Frond distromatic to pluriseriate.

α. Frond filaments without lateral appendages.

* Frond flabellate. Cortex of stipes running up on to base of frond.

a. Filaments 25—50 μ in diameter.

1. Constrictions of frond-filaments quite or almost equidistant above dichotomy. Filaments 25—70 μ in diameter. (Western hemisphere). . . . . 4. *U. conglutinata* (p. 114).

2. Constrictions of frond-filaments at markedly unequal distances above dichotomy. Filaments of frond 25—35 μ in diameter. (Eastern hemisphere). 6. *U. orientalis* (p. 119).

b. Filaments 50—65 μ in diameter. Supra-dichotomial constrictions even. (Eastern hemisphere) . . . . 7. *U. explanata* (p. 120).

** Frond cyathiform. Filaments 35—100 μ in diameter. Cortex of stipes ending abruptly, not running up on to frond . . . . . 5. *U. cyathiformis* (p. 117).

β. Frond-filaments with lateral appendages, unilaterally but interruptedly arranged (i. e. alternately unilateral).

* Appendages simple, truncate or subpeltate. . . . . 8. *U. indica* (p. 121).

** Appendages simple or 2—3-fid, acute, usually sessile.

1. Supra-dichotomial constrictions uneven. Main filaments about 30 μ in diameter. (Indian Ocean). . 9. *U. palmetta* (p. 122).

2. Supra-dichotomial constrictions even. (West Indies). Filaments 45—70 μ in diameter . . *U. spinulosa* var. *palmettoidea* (p. 125).

*** Appendages 2—8-pronged, stalked. (West Indies). Main filaments 46—84 μ in diameter, supra-dichotomial constrictions even. . . . . 10. *U. spinulosa* (p. 124).

B. Main filaments not visible in surface view, being concealed by a close cortex composed of numerous branchlets, simple or subdivided, contiguous. Frond not, or rarely, fissile.

a. Main filaments distromatic to pluriseriate. Cortex easily separable after decalcification. Lateral appendages short, of approximately equal length, very numerous.

1 Surface either smooth or spinose. Lateral appendages with a simple, nilated, or lobulate head.
a Main filaments 40—60 μ diameter (Indian Ocean). . 11. *U. argentea* (p. 125).
β Main filaments 30—45 μ diameter (West Indies) . . 12. *U. occidentalis* (p. 127).
2 Surface fibroid, minutely spiculoso-granulose or papillose. Lateral branchlets simple or forked, mostly shortly pedicellate, arranged in close subverticils or distichously secund.
a Lateral appendages spinose, acute. . . . . 13. *U. verticillosa* (p. 128).
β Lateral appendages very obtuse . . . . . 14. *U. Wilsoni* (p. 130).

B Filaments pluriseriate, requiring to be torn apart after decalcification. Cortex very coherent. Lateral appendages of unequal length.
1. Frond thick, much calcified; appendages mostly springing from opposite sides of the filament, at irregular intervals, cymoidly subdivided at apex. . . . . 15. *U. flabellum* (p. 131).

1. *Udotea javensis* A. & E. S. Gepp

in Journal of Botany XLIII. 1904. pp. 363—4. tab. 467, figs. 1—4.

Syn. *Rhipidosiphon javensis* Montagne Prodr. Phycolog. Antarct. 1848. p. 14.
Rhipidosiphon javensis Montagne in Dumont D'Urville's Voyage au Pole Sud, Bot. I. 1845. p. 23, pl. 7, fig. 3.
Udotea glaucescens var. *tenuis* or *tenuior* Grunow in Ferguson's Ceylon Algae n⁰ 439.
Udotea javensis Okamura Icones of Japanese Algae. I. 1908. p. 228, pl. XLV, figs. 1—7.

Hab. INDIC. Leyden, Batavia, *Hombron*! — Ceylon, *Ferguson*! — Maumeri, Flores, Dec. 1888, n⁰ 1037, *Madame Weber van Bosse*! — Macassar, Lei-lei, coral reef, Nov. 1888, n⁰ 932, *Madame Weber van Bosse*!
Siboga Expedition. Stat. 16. Kangeang Island reef! — Stat. 43. Island Sarasa, Paternoster Islands, reef! — Stat. 53. Bay of Nangamessi, Sumba, reef! — Stat. 71. Macassar reefs! — Stat. 79. Island Kabala dua, Borneo bank, reef! — Stat. 81. Island Sebankatan, Borneo bank, reef! — Stat. 125. Sawan, Siau Island, reef! — Stat. 213. Saleyer reef! — Stat. 248. Tiur Island, reef! — Stat. 261. Elat, Great-Kei Island, reef! — Stat. 282. N. E. point of Timor, reef! — Stat. 296. Bay of Noimini, South Coast of Timor, reef! — Stat. 299. Rotti Island, reef! — Stat. 322, Sankapura roads, Bawean Island, reef!
PACIFIC. Hiuga, Kiushiu, Japan, *Yendo* (well figured by Okamura, *loc. cit.*).

Stipes simple, erect, monosiphonous, smooth, not encrusted, sometimes radicelliferous, 60—100 μ thick.

Frond 2.5—30.0 mm. high, glaucescent-green, cuneate at base, rotundate and fimbriate, often lacerate above, flabellately expanded, formed by repeated dichotomy of the filaments, monostromatic, calcified.

Filaments laterally coherent by calcification, straight, smooth, mostly 45—50 μ thick (up to 100 μ at base). Supra-dichotomial constrictions uneven. Calcified sheath porose. [Fig. 36].

This species, formerly known as *Rhipidosiphon javensis* Mont., was made the type of the genus *Rhipidosiphon* and placed in Siphoneae by MONTAGNE (l. c.) in 1842. The plants

described had been collected by HOMBRON off Java, and since that time they had never been recorded in any later collection of marine algae, until our note and figures were published in the Journal of Botany (l. c.).

MONTAGNE (l. c.) described and figured *Rhipidosiphon* as a fan-shaped thallus composed of dichotomous and anastomosing filaments; and though in the Siboga collection we found several plants exactly like MONTAGNE's figure in size and habit, we were unable to detect in any of them the characteristic anastomosis insisted upon by MONTAGNE. So striking however was the resemblance, that it inevitably suggested the possibility that MONTAGNE had made some error in his observation. And so indeed it proved; for we discovered at last in one of our plants some instances of "anastomosis", or rather of pseudo-anastomosis. In other words, the so-called anastomosis observed by MONTAGNE was an anastomosis, not of the filaments of the flabellum, but of the lines of calcareous cement which fills the grooves between contiguous filaments and also forms a connecting ring round the constriction at the base of each supra-dichotomial branch. MONTAGNE in fact mistook the opaque lines of cement for filaments, as we endeavoured to shew by figures in Journal of Botany (loc. cit.). Finally, MONTAGNE's type in Herb. Mus. Paris is identical with the Siboga specimens and has no anastomosing filaments. Another synonym is *U. glaucescens* var. *tenuis* (or *tenuior*) Grunow in Ferguson's Ceylon Algae (n° 439).

U. javensis is the simplest form of *Udotea*, being characterised by a permanently monosiphonous stipes, simple, uncorticated and translucent, and by its small monostromatic flabellum of filaments destitute of all lateral appendages.

Its nearest allies are *U. papillosa* and *U. glaucescens*. From *U. papillosa*, which it closely resembles in size, it differs in being entirely destitute of papillae on the filaments of the frond. From *U. glaucescens* it differs in having a permanently monosiphonous stipes. In *U. glaucescens* the stipes is monosiphonous in young plants only, and later becomes compound and clothed with a cortex, produced by a multitude of lateral branchlets. Curiously enough there is in the Siboga collection from Noimini Bay, Timor, a composite specimen which in its frond exhibits filaments of *U. papillosa* chiefly, with a few filaments of *U. javensis* intercalated side by side.

U. javensis occurs in the Indian Ocean and on the shores of Japan.

2. *Udotea papillosa* n. sp.

Hab. INDIC. *Siboga Expedition.* Stat. 296. Bay of Noimini, Timor reef! — Stat. 16. Kangeang Island, reef! — Stat. 322. Sankapura roads, Bawean, reef!

Plant usually small, reaching a height of about 2 cm. Stipes (or primary filament), when young, simple, erect, monosiphonous, papillate above, not calcified, 70—100 μ in diameter; in plants exceeding 1 cm. in height, this primary stipes becomes more or less concealed by a covering of descending rhizoids issuing from it at different levels.

Frond thickly calcified, usually about 1 cm. long, and 0.5—1.0 cm. wide (4.5 cm. long and 2 cm. wide in subsp. *subpapillata*), cuneato-flabelliform, monostromatic, striate, not zoned in type, often deeply lacerate, here and there proliferous.

Filaments 30—45 μ in diameter (without papillae), laterally coherent in one plane by means of calcification, straight, bearing numerous approximated obtuse or mamillately apiculate conical papillae, arranged in single or double rows along the front and back of the filament, usually arising pair-wise exactly opposite one another; on the basal filaments they form close whorls here and there, and occasionally are forked or geminate. Supra-dichotomial constrictions uneven. [Figs. 17, 20, 24, 37, 38].

subsp. *subpapillata* n. subsp.

Hab. Indic. *Siboga Expedition.* Stat. 285. South Coast of Timor. 34 meters. Lithothamnion bottom!

Plant 5 cm. high. Frond 4.5 cm. long, 2 cm. wide, zonate. Differs from the type in having much shorter and more obtuse papillae, often inconspicuous, and at somewhat wider intervals on the filaments of the frond. The frond filaments are about 30 μ in diam. above and about 55 μ at base, where they are irregularly beset with short fibulae 30—70 μ long. (see fig. 41). [Figs. 39—42].

U. papillosa (fig. 37), which in general habit resembles *U. javensis* (fig. 36) is one of the simplest of the genus. Small specimens were found preserved in spirit together with equally small plants of *U. javensis*, from which species *U. papillosa* may usually be distinguished, even before decalcification, by its opaque and perforated appearance (fig. 20) when seen under the microscope. When decalcified and teased out, the filaments composing the frond are seen to be papillose (fig. 24), the papillae being arranged for the most part in single or double opposite rows on front and back of the frond. They vary in shape even in the same filament, being usually either obtusely conical or mamillately apiculate, usually simple, but occasionally geminate near the base of the plant; sometimes also they are arranged in whorls on the basal filaments or on the stipes of the proliferations (fig. 38). These whorls or subwhorls and opposite pairs of papillae are interesting in view of the normal arrangement of the lateral appendages in *U. verticillosa* (fig. 23) or *U. Wilsoni* (fig. 38). In subsp. *subpapillata* (fig. 39) the papillae are low, broad, inconspicuous bosses on the upper filaments (fig. 42); near the base (figs. 40, 41) they are obvious and long (fibulae). The function of the papillae appears to be either to maintain a plentiful and easy communication by osmosis between the interior of the filament and the circumambient sea-water, or to permit of a readier access of light into the cell-cavity which is rendered dark by the thickness of the calcareous deposit which coats the frond (see pp. 5 and 102, 103). The papillae, reaching to the surface of the calcareous coating appear as translucent areolae in the opaque frond (fig. 20).

In mature plants, the primary filament becomes hidden by a covering of descending rhizoids or prolonged outgrowths of the papillae (fig. 37). The older the plant, the thicker the covering, just as in *U. glaucescens*; but in *U. glaucescens* there is an additional tomentose layer of "fibulae" (compare top of fig. 43), which conceal and bind together the component filaments of the stipes, and extend over the base of the flabellum. Such "fibulae" are very feebly developed in *U. papillosa* (type), being in fact merely elongate papillae.

The subsp. *subpapillata* (fig. 39) is described from a single specimen only, which was

obtained from deep water (23 fathoms). It is more than twice as large as the type, has a delicate thin frond, and differs in having in its upper filaments (fig. 42) much less prominent papillae which are more widely spaced out, and in having the base of the flabellum beset with fibulae (fig. 40). Possibly its differences are due to the depth at which it grew. At first sight it is remarkably like *U. glaucescens*. Having only the one specimen and that from deep water only, we hesitate at present to carry out our intention of publishing this plant as a new species under the name — *Udotea subpapillata*. We have however placed it as a species in the table of affinities (p. 7).

As mentioned under *U. javensis*, we have found among the specimens from Noimini Bay, Timor, a frond of *U. papillosa* containing a fortuitous intercalation of filaments of *U. javensis*, growing amicably side by side. The geographical distribution, as at present known, is confined to the Malay Archipelago, where it is found with *U. javensis*.

3. *Udotea glaucescens* Harv.

List of Friendly Islands Algae, n° 82 (nomen tantum).
Syn. *Udotea glaucescens* J. G. Agardh Till Alg. Syst. V. 1887. p. 70.
Udotea glaucescens De Toni Syll. Alg. vol. I. 1889. p. 505.

Hab. INDIC. Cargados Carajos, 30 fathoms, *J. Stanley Gardiner*! — Sumatra, *Wray*, in Herb. Kew! *Siboga Expedition*. Lirung! with monosiphonous stipes.
PACIFIC. In the lagoon, Tongatabu, Friendly Islands Algae, *Harvey* n° 82! — Rawa, Feejee Islands, 1850, *Harvey* in Herb. Kew! — Cape York, North Australia, "*Challenger*" Expedition! — Torres Straits, "*Challenger*" Expedition!

Plants varying in length to about 8 cm., encrusted with lime, radicelliferous below. Stipes simple, sometimes once branched, sometimes sparingly divided at apex, up to 4 cm. long, monosiphonous at first, subsequently becoming covered with descending branches and a thick cortex of fibulae or lateral appendages.

Frond from a cuneate or rounded base, flabellate, typically monostromatic (except sometimes at base), sometimes consisting of two or more loosely superposed lamellae arising from the inconspicuously divided top of the stipes, glaucescent, not zoned, not corticated.

Main filaments of the frond more or less calcified, 65—105 μ in diameter, radiating from the stipes to the margin, parallel, dichotomously or rarely trichotomously branched, unequally constricted above the dichotomies, laterally adherent, not flexuose.

Filaments of stipes of mature plant bearing lateral appendages which terminate in short, simple or lobed, truncate capitula, botryoidally arranged, and form an irregular cortex to the stipes. [Figs. 3, 5, 7, 8, 43].

Udotea glaucescens Harvey existed first only as a herbarium-name to denote plants found by HARVEY in the Friendly Islands, and distributed as n° 82 in his List of Friendly Islands Algae (fig. 3). It was first described by Prof. J. G. AGARDH (Till Alg. Syst. l. c.), who likens the thallus to the frond of *Rhipocephalus*. Its chief characteristic is the monostromatic frond composed of parallel, closely adherent filaments (fig. 5), which branch dichotomously

and bear no lateral appendages (fig. 71). This character it has in common with *U. javensis* (fig. 30), but from that species it is distinguished by its stouter frond-filaments and by its stipes, which, monosiphonous at first, puts out several descending branches or rhizoids (fig. 43); these branches become bound together into a compact column by means of small lateral appendages, which form a loose cortex around the main filaments. The stipes of *U. javensis* on the other hand consists permanently of a single uncorticated filament, which sometimes throws out a number of rhizoids (fig. 30*a*).

The only representative of this species in the Siboga collection was gathered at Lirung, near Celebes. It agrees with HARVEY's authentic specimens in the characters of its frond-filaments and the fibulae at the base of the frond. It is a small plant, but an important and instructive one in respect of its stipes. The stipes is very long and monosiphonous, thinly covered by long descending branches or rhizoids; and at its upper end it has begun to be fibuliferous (fig. 43). It is an indication of the process of development of the compact stipes of the mature plant. (Compare also the stipes of *U. papillosa*, p. 112).

HARVEY's Friendly Islands specimens are but thinly calcified, having therefore a green appearance, and their frond-filaments measure 65—70 μ in diameter. The specimens collected at Torres Straits by the "Challenger" Expedition are more calcified and have an ashy-grey colour, with filaments of similar dimensions. Mr. STANLEY GARDINER's specimens from Cargados Carajos were dredged up from a depth of 30 fathoms; they are larger, with simple flabelliform fronds, rotundate at base, monostromatic and not lamellate; the frond-filaments have a diameter of 70 μ in young green specimens, varying up to 105 μ in mature well-calcified filaments.

U. glaucescens differs from *Udotea orientalis*, also an Eastern species, in having a monostromatic frond composed of parallel, closely adherent, filaments; while the frond of *U. orientalis* (fig. 1) is pluriseriate and composed of filaments which are very much smaller, flexuose and not closely parallel.

The distribution is confined to the Indian Ocean and tropical Pacific.

4. *Udotea conglutinata* Lamouroux

Hist. Polyp. Corall. Flex. 1816. p. 312.

Syn. *Corallina conglutinata* Ellis and Solander Nat. Hist. Zoophytes. 1786. p. 125, tab. 25, fig. 7.
Corallina conglutinata Gmelin, Linn. Syst. Nat. vol. I. part VI. 1790. p. 3843.
Corallina conglutinata Bosc Hist. Nat. des Vers (Suites à Buffon). vol. III 18mo Paris (Déterville). 1802. p. 71.
Flabellaria conglutinata Lamarck Sur les Polyp. empâtés in Ann. d. Mus. d'Hist. Nat. XX. 1813. p. 301.
Flabellaria conglutinata Lamarck Anim. sans Vertèbres tom. II 1816, p. 343; also op. cit. ed. II tom. 2, 1836, p. 526.
Corallina conglutinata Cuvier Regne Animal. IV 1817. p. 77.
Udotea conglutinata Lamouroux Expos. Meth. 1821. p. 28. tab. 25, fig. 7.
Udotea conglutinata Deslongchamps in Encyclop. Meth. Zoophyt. 1824—5. p. 762.
Udotea conglutinata Blainville in Dict. Sci. Nat. LVI. 1828. p. 229.
Udotea conglutinata Blainville Man. d'Actinolog. 1834. p. 558.
Flabellaria conglutinata Chauvin Recherches 1842. p. 123.
Udotea conglutinata Kutzing Species Algarum 1849. p. 502.

Udotea conglutinata Duchassaing Animaux Radiaires des Antilles. Paris 1850. p. 29.
? *Penicillus comosus* Schramm et Mazé Algues de la Guadeloupe Edit. I. 1865. p. 44. [See p. 91]
Udotea conglutinata Farlow in Proc. Amer. Acad. X. 1875. p. 377; U. S. Fish Comm. Report. III. 1876. p. 711.
Udotea conglutinata J. G. Agardh Till Alg. Syst. V. 1887. p. 72.
Udotea conglutinata Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Udotea conglutinata De Toni Sylloge Algarum I. 1889. p. 507.
Udotea conglutinata Howe in Bull. Torrey Bot. Club XXXVI. 1909, p. 96; pl. 2 & pl. 8, figs. 11—13.
Udotea conglutinata Howe in Journ. New York Bot. Gard. IX. 1908. p. 126, fig. 19.
Udotea conglutinata Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 395.

Hab. Atlantic. Among "Plants & Submarines gathered at Carolina, Bermuda & the Caribbees by the *Rev. Mr. Clerk*" in Herb. Sloane vol. 318. fol. 42. n° 8! fol. 48. n° 11! — Key West, Florida, in *Herb. Mus. Brit.*! — Florida, *W. G. Farlow* in Herb. Collins! and in *Herb. Weber van Bosse*! — Bahia Honda Key, *Curtiss*, Algae Floridanae ser. I! — Bahamas, Bemini Harbor, *Howe*, n° 3240! — St. Croix, *F. Börgesen*, herb. n° 1480*a*!

Plants much calcified, varying in length to about 9 cm. Root-mass bulbous to elongate. Stipes simple, 1—2.5 cm. long, varying to 0.5 cm. thick, corticated, cortex finely spongiose or velutinous, subterete below, flatly expanded and cuneate above and (in structure) passing gradually into the flabellum, the base of which is corticated.

Frond narrowly or widely flabelliform to subreniform, up to 7 cm. long and 11 cm. wide, pluriseriate, plane, sometimes divided above into 2—3 wide overlapping lobes, often zoned, green to ashy-white, surface minutely and longitudinally filamentoso-striate above, velutinous or spongiose towards and at base; margin subentire to eroso-lobate.

Filaments of frond 25—50 μ (rarely 70 μ) in diameter, here and there larger, calcified, radiating from the stipes to the margin, repeatedly dichotomous, as a rule evenly constricted above the dichotomies, flexuose, pluriseriate, somewhat felted and conglutinated together and stiffened by calcareous deposit. Filaments at base of frond, for a short distance above the transition from stipes, concealed under a loose covering of fibulae or lateral branchlets, shorter and simpler than those of the stipes.

Filaments of stipes bearing lateral branchlets, dichotomously divided, and terminated by apices which vary from dactyline to abbreviated and obtuse, and are approximated together so as to form an external cortex, hardened by a calcareous deposit. [Figs. 44—46].

The type of this species is, as stated above, the *Corallina conglutinata* of Ellis and Solander; and though unfortunately the original plant has been lost, it is quite easy to grasp the identity of this species. The main characteristic, which is implied in the name, to wit, the "branches dichotomous and glued together, but not covered" is further explained in the following note by the authors (loc. cit. p. 125): "We can plainly distinguish all the dichotomous "branches of this Coralline on its surface, which are each of them separately covered with a "thin calcareous substance full of pores; these, by growing so close to one another, become "glued or united together by their covering. This was found on the coast of the Bahama "islands. It is of a seagreen color, and one inch and an half high". This makes their species tolerably unmistakeable and supplements what is poorly rendered in their fig. 7 on tab. 25.

Lamarck founded his *Flabellaria conglutinata* (1813 loc. cit.) and Lamouroux his *Udotea conglutinata* (1816 loc. cit.) upon the description, figure and habitat of Ellis and Solander, apparently without having seen specimens of the plant. And Lamouroux at least does not seem to have realised the identity of the plant, for he gave the name of *U. conglutinata* to a specimen which clearly is *U. flabellata*. It is labelled in Lamouroux's handwriting and a photograph of it is in the Herbarium of the British Museum.

Decaisne also failed to realise the difference between *U. conglutinata* and *U. flabellata*. For though his description of *U. flabellata* clearly and truly represents that species, yet in its synonymy he includes *Flabellaria conglutinata* of Lamarck, which as shown above is the true *U. conglutinata* of the present day. Further he cites in his synonymy of *U. flabellata* the following — "Corallina — Sol. et Ell. p. 125 t. 24". The omitted specific name is presumably intended to be *conglutinata* since the dash is placed immediately under the specific name "*conglutinata*" (used in the "*Flabellaria conglutinata* Lmk." in the preceding line). On the other hand Decaisne cites also the tab. 24 of Ellis and Solander which represents the true *U. flabellata* of the present day. Thus Decaisne evidently confused Ellis and Solander's two species.

U. conglutinata has often been confounded with *U. cyathiformis* Decne. and the fundamental differences between the two species were never defined satisfactorily until the publication of Dr. M. A. Howe's observations in Bull. Torrey Bot. Club XXXVI. 1909 pp. 94—97. Dr. Howe has collected plants of both species representing successive stages of growth and reproduces a most instructive series of photographs (loc. cit. plates 2. 3) in illustration, which prove that from quite an early stage typical *U. cyathiformis* is infundibuliform, and *U. conglutinata* is flabellate.

We have at times had difficulty in distinguishing herbarium specimens of these two species in consequence of the variability of the habit and structure in each. But we are inclined to regard the following as the most useful characters for discriminating between the two species.

In *U. conglutinata* the frond is plane (fig. 44), non-fissile, the filaments being matted and conglutinated together; the stipes is flattened above and passes gradually and cuneately into the flabellate frond; the base of the frond is covered with a cortical coating of short lateral appendages (fibulae), and the upper part usually has a tomentulose nap-like surface. The felting of the filaments is due to their much-repeated dichotomies; and the nap-like surface is due to the short, tortuous, and often somewhat divaricate ultimate branchlets (see Howe op. cit. p. 96).

In *U. cyathiformis* the frond of typical specimens is cup-shaped (fig. 2) (in dried specimens the frond is liable to be expanded and flattened out, thus losing its hollow shape); in typical specimens the stipes is cylindrical throughout and passes abruptly into the frond, and the base of the frond is destitute of corticating fibulae; the frond is fissile and its surface is fibrous, or resembles coarse appressed nap. The lateral appendages of the stipes bear terminal cymoid groups of minute capitate apices (similar to that shown in fig. 8 *b*).

U. cyathiformis in its typical infundibuliform state is quite distinct and easily recognised. But the question is complicated by the existence of plants with an explanate frond. These

appear to be identical with *U. cyathiformis* in almost every character except the possession of a cyathiform frond. And, since they occur in the same geographical region as, and in association with, that species, it seems impossible to exclude them from *U. cyathiformis*. For instance, n° 99 of Mazé's Algues de la Guadeloupe in Herb. Mus. Brit. has a plane, narrow, cuneato-flabelliform frond, while the specimens under the same number in Herb. Kew are evidently cyathiform. There are also in Madame Weber van Bosse's herbarium five spirit specimens collected at Santa Marta, Columbia, by Dr. Versluys, all of which have a purely explanate frond with rotundate base, and which, but for their geographical origin, we should place without hesitation under our East Indian species, *U. explanata* (see remarks under that species, p. 121).

For distinguishing such flabelliform plants from *U. conglutinata* the most trustworthy characters are the thin, flexible, fissile, fibrous frond, usually destitute of fibulae at base; the less frequent dichotomies of the frond-filaments; and the truncate or button-like apices of the lateral appendages of the stipes.

As regards their diameter, the frond-filaments of *U. conglutinata* are rather variable; for instance, in Dr. Howe's n° 3240 (fig. 44) from the Bahamas (the type locality) they vary from 30 to 50 μ in diameter, while those of the ancient specimens of the Rev. Mr. Clerk in Herb. Sloane vary between 38 and 54 μ in one plant and 45 to 70 μ in another plant. This latter, though exceptional, is an undoubted *U. conglutinata*, with typical habit and a fibular coating on the lower part of the frond.

The size of the frond-filaments is thus an insufficient character for the separation of *U. conglutinata* from *U. cyathiformis*. For in *U. cyathiformis* there is a group of plants in which the diameter of the frond-filaments varies between 35 and 50 μ.

The lateral appendages of the stipes of *U. conglutinata* seem to be more variable in shape than those of *U. cyathiformis*, bearing apices which range from dactyline (fig. 46) to short, obtuse, or truncate, simple or bifid, in groups of two, 10—20 μ thick (rarely 30 μ), not capitate.

Udotea conglutinata is recorded only from the tropical Atlantic.

5. *Udotea cyathiformis* Decaisne

Mém. sur les Corallines ou Polyp. Calcif. in Ann. Sci. Nat. 2de sér. tom. XVIII. 1842 p. 106.
Syn. *Udotea acetabulum* Decaisne MS. in Herb. Mus. Paris.
Udotea cyathiformis Kutzing Species Algarum 1849. p. 503.
Udotea conglutinata Harvey Nereis Bor. Amer. III 1858 p. 27. pl. XL. C (probably).
Flabellaria conglutinata Mazé et Schramm Algues de la Guadeloupe. Ed. II. 1870—77. p. 88.
Udotea conglutinata Dickie in Journ. Linn. Soc. (Bot.) XIV. 1874. p. 312 (pro parte), and p. 315 (pro parte).
Codium infundibulum Suhr ex J. G. Agardh Till Alg. Syst. V. 1887. p. 71.
Udotea infundibulum J. G. Agardh loc. cit.
Udotea conglutinata Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Udotea cyathiformis Murray op cit. p. 239.
Udotea infundibulum De Toni Syll. Alg. I. 1889. p. 507.
Udotea cyathiformis De Toni op. cit. p. 512.
Udotea conglutinata Vickers and Shaw Phycologia Barbadensis. Paris 1908 p. 24, pl. XXXII.

Udotea conglutinata f. *infundibuliformis* A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908 p. 178, and loc. cit. (Zool.) XII. 1909 p. 388.
Udotea cyathiformis Howe Bull. Torrey Bot. Club XXXVI. 1909 p. 96, pl. 3; pl. 8, figs 8—10.
Udotea spathiformis Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 395.

Hab. ATLANTIC. "Iles des Saintes près la Guadeloupe," *D'Ivernauville* in Herb. Mus. Paris sub nom. "*U. Acetabulum*"! — Guadeloupe, Saintes, Anse sous le vent, sur la coquille du *Strombus*, 7 Fevrier 1870, *Mazé* n° 1358 bis! — Guadeloupe, Basseterre, sur la coquille du Strombus gigas, 25 Nov. 1864, *Mazé* n° 99, première série! — Guadeloupe, Saintes (anse du Marigot), sable vaseuse, eaux tranquilles, en Fevrier, *Mazé* n° 150 bis! — "W. India" Suhr (sub nom. "*Udotea infundibulum*")! — St. Thomas, "*Challenger*" Expedition, 5—15 fathoms! — St. Thomas, *F. Borgesen*, herb. nos 1019 (15 fathoms), 1101 (15 fathoms), 1137 (20 fathoms), 1173 (15 fathoms)! — St. Croix, *F. Borgesen*, herb. n° 1596 (5 fathoms)! — St. Jan, *F. Borgesen*, herb. nos 1823, 2248, and an unnumbered specimen! — Pedro and Morant Cays, Gulf of Mexico, 2—100 fathoms, *Carpenter*! — Bahama Bank, *F. M. Rayner* in Herb. Mus. Brit.! — Bermuda, "*Challenger*" Expedition, 31 fathoms in Herb. Mus. Brit.!, 30 fathoms in *Herb. Kew*! — Bahamas, Exuma Chain, Cave Cays, *Howe* n° 3976! — Columbia, Sta Marta, baie de Tagauga, explanate examples dredged 18. II. 1896, yacht "Chazalie", *Verstuys*! in Herb. Weber van Bosse.

Plants varying in length to about 17 cm. high, moderately calcified, rather flexible. Root-mass bulbous to elongate. Stipes simple, terete, or sometimes flatly expanded above, up to 5 cm. long and 0.6 cm. thick, corticated, usually passing abruptly into the frond; cortex smooth, very minutely pseudoporose.

Frond cyathiform, or split open and explanate, sometimes flabelliform, up to 11 cm. long and 9 cm. wide, fissile, often more or less deeply lacerate, often zoned, green to ashy-white, superficially fibrous or resembling coarse appressed nap; margin usually lacerate or fimbriate.

Filaments of frond about 40—100 μ in diameter, calcified, radiating from the stipes to the margin, evenly constricted above each dichotomy, somewhat flexuous, pluriseriate, not conspicuously conglutinated together as in *U. conglutinata* and less frequently dichotomous than in that species.

Filaments of stipes bearing lateral appendages, dichotomously divided, and terminated by truncate, cymoid heads of abbreviated capitate apices, approximated together to form a cortex, which is hardened with a calcareous deposit. (See Howe in Bull. Torrey Bot. Club. XXXVI. 1909. pl. VIII, figs. 8—10) [Fig. 2, 6, 9].

This species was founded in 1842 by DECAISNE (loc. cit.) and the type is evidently the specimen labelled by DECAISNE *U. acetabulum* in Herb. Mus. Paris, and kindly lent to us (fig. 2). Another example of the same species is the *Codium infundibulum* of Suhr (*Udotea infundibulum* J. Ag.). Through the kindness of Major REINBOLD we have been enabled to see and examine SUHR's original plant, which is a small specimen of *U. cyathiformis* Decne. and resembles the type in the small size of its filaments (about 40—50 μ). SUHR's plant is labelled as coming from "W. India", meaning presumably the West Indies, and before it came into Major REINBOLD's possession was preserved in the Herbarium of Prof. JESSEN, the friend and pupil of SUHR. J. G. AGARDH (Till Alg. Syst. V. p. 71) quotes the East Indies, "ad oras Indiae orientalis (fide Suhr)", as the locality for this plant, but he remarks later that the

locality is doubtful. His description agrees precisely with the plant which Major Reinbold lent us. The supra-dichotomial constrictions are usually formed above the dichotomy at a distance equal to the diameter of the filament.

U. cyathiformis differs from *U. conglutinata* in having normally a cup-shaped and not a flabelliform frond. Recently Dr. Howe (loc. cit.) has demonstrated that the fundamental difference of habit which distinguishes the two species obtains even in young plants; as is shewn in his series of photographic reproductions (loc. cit. plates 2, 3.).

Too much dependence must not however be placed on this character (difference of habit) alone, in view of the occasional occurrence of specimens of *U. cyathiformis* with a purely flabelliform frond. For example Mazé's n° 99 from Guadeloupe in Herb. Mus. Brit. would pass at first sight for *U. conglutinata*, were it not for other characters. It should be noted that the corresponding specimens in Herb. Kew shew a cyathiform tendency. We have summarised the most trustworthy characters for distinguishing the two species in our remarks under *U. conglutinata* (p. 116).

The specimens of *U. cyathiformis*, which we have seen, fall into two groups according to the size of their frond-filaments. On the one hand, the filaments of the frond measure 35—50 μ in diameter in Decaisne's type from Guadeloupe (fig. 6), and in Suhr's *Codium infundibulum*, and in Mazé's n°. 99 from Guadeloupe. The other group consists of specimens whose frond-filaments measure between 50 and 100 μ; for example, Mazé's 1358bis from Guadeloupe. And this latter group is the commoner of the two.

The geographical distribution of *U. cyathiformis* is confined to the West Indian region.

6. *Udotea orientalis* n. sp.

Syn. *Udotea suborbiculata* Sonder in F. von Mueller's Fragm. Austral. XI. Suppl. 1880. p. 38. sub n° 973.
Udotea Palmetta J. G. Agardh Till Alg. Syst. V. 1887. p. 71.
Udotea infundibulum Hauck in Hedwigia XXVII. 1888 p. 92.
Udotea Palmetta De Toni Syll. Algarum I. 1889. p. 506.
Udotea infundibulum Hieronymus in Engler Pflanzenwelt Ostafrikas. Theil C. p. 24. 1895.
Udotea conglutinata Okamura Icones of Japanese Algae I. 1908. p. 231, plates XLIV, figs. 11, 12, XLV, figs. 8—13.
Udotea conglutinata A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908. p. 175; and in Trans. Linn. Soc. (Zool.) XII. 1909. p. 385.

Hab. Indic. *Siboga Expedition.* Stat. 64. Island Tanah-Djampeah, 30 m. n^{os} 261! 262! 263! — Stat. 99. Island North Ubian, Sulu Archipelago, 16 m.! — Stat. 133. Lirung, Salibabu Island, reef! — Stat. 301. Pepela Bay, Rotti Island, reef!
Lamu Harbour, Zanzibar coast, covered at low water, *Hildebrandt*, n° 1918! — Bluff, Natal, *Evans*! — Durban, Natal, *Weber van Bosse*!
Pacific. Queensland, Cape Gloucester (*fide Sonder*). — Queensland, Cape Flattery, Algae Mullerianae in *Herb. Kew*! — Queensland, Brammo Bay, Dunk Island, *Banfield*! — Queensland, Port Denison, *fide J. G. Agardh.* — Macclesfield Bank, China Sea, *Bassett Smith*! — Japan, Riukiu, *Kuroiwa*, *Ando*, and *Kanagusuku* (well figured by Okamura, loc. cit.).

Plants varying to about 7 cm. in length, usually about 5 cm., more or less calcified. Root-mass bulbous to elongate. Stipes simple, up to 2 cm. long, 1—2 mm. thick, corticated

(cortex spongy or velutinous), flattened above and in structure passing gradually into the flabellum.

Frond from a usually cordate, rarely cuneate, rarely auriculate base, subrotundate to flabelliform, about 3.5 cm. long, and 5 cm. wide, greenish-white, zoned, surface minutely and longitudinally filamentoso-striate above, velutinous or spongiose towards and at base, margin subentire, erose or occasionally lobate.

Frond-filaments 25—35 μ in diameter (rarely 45 μ), slightly calcified, radiating from stipes to margin, repeatedly dichotomously branched, unevenly constricted above each dichotomy, flexuous, pluriseriate, usually densely conglutinated together by calcareous deposit. Filaments at base of frond bearing a few short, simple, lateral branchlets or fibulae (compare Okamura loc. cit. pl. XLIV, fig. 11).

Filaments of stipes bearing lateral appendages, dichotomously divided and terminated by small, short, obtuse, sometimes ovoid, apices. [Figs. 1, 4, 47, 48].

This species (see fig. 1) is the parallel in the Indian Ocean of the West Indian *U. conglutinata* (fig. 44), from which it differs essentially in having the supra-dichotomial constrictions of its frond-filaments very unevenly situated (compare fig. 47 with fig. 45). Also *U. orientalis* is more slender than the West Indian species, and its frond-filaments have a slightly smaller diameter.

It should be noted that *U. orientalis* (fig. 47) and its ally, *U. glaucescens*, as well as *U. indica* and *U. palmetta*, all inhabitants of the Indian Ocean, have the characteristic uneven supra-dichotomial constrictions, which distinguish *Chlorodesmis comosa* (figs. 72, 73 *b*) of the Indian and Pacific Oceans. The West Indian species, *U. conglutinata* and *U. cyathiformis*, are distinguished at once by their even constrictions.

The distribution of *U. orientalis* lies between Timor, Celebes, and Macclesfield Bank on the east and Zanzibar and Natal on the west. The number of specimens in the Siboga collections shows that the plant is not uncommon in the Malay region. The Natal plants are deep green in colour and diverge from the type in having stouter frond-filaments reaching 45 μ in diameter (but with the uneven constrictions typical of *U. orientalis*), and in the stouter apices of the lateral appendages of the stipes-filaments.

The geographical distribution of *U. orientalis* is within the Indian and Pacific Oceans.

7. *Udotea explanata* n. sp.

Syn. ? *Flabellaria Palmetta* Kutzing Tab. Phyc. VIII. 1858 p. 12, tab. 27. fig. 1.
? *Udotea Palmetta* Sonder ex Kutzing loc. cit.
? *Udotea Kutzingii* De Toni Sylloge Algarum I. 1889 p. 511.

Hab. INDIC. *Siboga Expedition.* Celebes! — ? Arabian Gulf, Sonder.

Plant about 7.5 cm. high. Stipes 1.5 cm. high, cylindric below and 2 mm. thick, flattened above to a width of 5—6 mm. and in structure passing gradually into the flabellum; cortex of stipes spongy-velutinous, continued on to the base of the frond for a distance of about 2 mm.

Frond from a truncate base semicircular, with a radius of about 5 cm. from the stipes, fissile, much and deeply lacerated, with margin lobate and ragged through unequal growth, indistinctly zoned, isabelline, fissile, not much conglutinated, surface fibrous or like appressed nap.

Filaments of frond mostly 50—65 μ in diam., radiating from stipes to margin, pluriseriate, parallel, nearly straight, calcified, porose, with even (never with markedly uneven) constrictions.

Filaments of stipes bearing lateral appendages dichotomously divided and terminated by cymes of small, short, obtuse or truncate apices. [Figs. 49—51].

This plant is rather perplexing, and we have only one specimen of it (fig. 49). Though a product of the Indian Ocean, it lacks the markedly uneven supra-dichotomial constrictions, which are so characteristic of the other species of *Udotea* indigenous to Eastern waters. Its constrictions are even (fig. 50), like those of most of the West Indian species. Compared with the East Indian species it differs from *U. orientalis* in having its frond-filaments about twice as thick; and from *U. glaucescens* in having a pluristromatic frond. As to the West Indian species, it differs from *U. conglutinata* in its larger frond-filaments and its fibrous, fissile, non-conglutinated frond; and from *U. cyathiformis* in its purely explanate (not cup-shaped) frond, and in the continuation of the stipes-cortex on to the base of the frond.

We have alluded on p. 117 to the striking resemblance between the unique specimen of the present East Indian species and the explanate American specimens of *U. cyathiformis* collected by Dr. VERSLUYS at S^{ta} Marta in Columbia. Were it not for the widely separated habitats of the two gatherings, we should not hesitate to combine them in one species. But, in view of the limited distribution which characterises all the species of *Udotea* with the one exception of *U. flabellum*, we prefer for the present to regard the Celebes and the S^{ta} Marta plants as specifically distinct. The Celebes plant represents a purely explanate species, viz., *U. explanata*, while the S^{ta} Marta examples represent an explanate variant of *U. cyathiformis*. The discovery of cyathiform examples in the East Indian Archipelago would involve the merging of *U. explanata* in *U. cyathiformis*. And if on the other hand the S^{ta} Marta plants should prove to be always purely explanate, they would have to be referred to *U. explanata*. In either case we should arrive at a species which in its distribution leaps at one bound from the East to the West Indies or vice versâ.

We have never had the good fortune to see the plant figured by KÜTZING (loc. cit.) as "*Flabellaria Palmetta* (in sinu arabico. Herb. Sonder)". KÜTZING's figure however is so like our plant as to suggest that it is the same species. Both plants came from the waters of the Indian Ocean; both have a pluristromatic and fibrous, fissile frond; both have the supra-dichotomial constrictions even and frond-filaments of about the same diameter. We assume of course that KÜTZING's figure of the filaments is accurate both as to shape and size. We also assume that "in sinu arabico" indicates either the Red Sea or the Arabian Sea.

8. *Udotea indica* n. sp.

Hab. INDIC. Kurrachee, Sind, 1880—3, *J. A. Murray* in Herb. Mus. Brit.! sub "*Udotea Desfontainii* Decne." in Dickie's MS. 90, 90A, 90B 3/82, 90C 3/82, in Herb. Kew *J. A. Murray*! — Kurrachee, sub nom. "*Udotea conglutinata*" (Harvey's MS.), "*Cyclops* Dec. 59. C.C.T." in Herb. Kew!

Plants up to 6 cm. long and as much broad, slightly calcified. Root-mass a small tuft. Stipes simple, slender, to about 1 cm. long, about 1 mm. thick. Frond rotundato-flabellate, orbicular, panduriform-obovate or irregular, often bearing a broad prolification above, usually rounded at base but sometimes slightly cuneate, sometimes subcordate, green or faded, conspicuously zonate, margin entire, lobed or lacerate.

Filaments of frond about 40 μ in diameter, radiating from the stipes to the margin, subparallel, subflexuose, congested, pluriseriate to triseriate, those of the different layers crossing obliquely, dichotomously but inconspicuously branched, the supra-dichotomial constrictions being markedly uneven, filaments bearing here and there numerous unilateral, short, peltate or abruptly truncate papillae, usually simple, sometimes bilobate, borne only on the exposed surface of the filament (i.e. external to the frond); filaments bare of papillae within the frond. Papillae fitting together at their edges so as to form a primitive cortex.

Filaments of stipes much and irregularly dichotomously branched, having lateral branches with dichotomously divided ends which form an external cortex. [Figs. 13, 14, 52, 53].

This species of which we have seen more than 30 specimens, all collected at Kurrachee, near the mouth of the Indus, by J. A. Murray, has, so far as we know, never been found elsewhere. In habit it is not unlike green specimens of *U. orientalis*, but it is much more like *U. palmetta* in possessing lateral appendages. In *U. indica* the appendages are short, peltate, or truncate button-like papillae (fig. 13), and are generated only on the outer surface of the superficial filaments of the frond (see Introduction p. 3). Where a filament dips under another filament or passes into the interior of the frond, there it is entirely destitute of papillae (fig. 53). Hence the unilateral and interrupted occurrence of the papillae upon the filaments (fig. 13 *a*, *b*). These truncate papillae, fitting close together side by side almost all over the frond, form a primitive cortex. In *U. palmetta* the lateral appendages are pointed conical spines, simple, or shortly bifurcated or trifurcated, but always with acute apices.

9. *Udotea Palmetta* Decaisne

in Essai sur Classific. d. Algues etc. in Ann. Sci. Nat. 2me sér. tom. XVII. 1842 p. 380. pl. 17, fig. 15; also Mém. sur les Corallines Op. cit. XVIII 1842 p. 105.

Syn. *Udotea Palmetta* Kützing Species Algarum 1849 p. 503. (non Tab. Phyc. vol. VIII. 1858. p. 12. tab. 27.)

Udotea Palmetta Gepp in Trans. Linn. Soc. (Bot.) VII. 1908 p. 175; also (Zool.) XII. 1909 p. 385.

Udotea Palmetta Howe in Bull. Torrey Bot. Club XXXVI. 1909. p. 98.

Hab. Indic. Cargados Carajos, 45 fathoms, *J. Stanley Gardiner*! — Sine loco, Herb. du Petit-Thouars in *Herb. Mus. Paris*!

Plants varying in length to about 13 cm.; moderately calcified. Root-mass small, bulbous to elongate. Stipes simple, slender, to about 4.5 cm. long, and about 2 mm. thick. Frond flabelliform, suborbicular from a cordate base, greyish-green, conspicuously zoned, margin entire, sometimes lacerate, sometimes proliferating above.

Filaments of the frond about 30 μ in diameter, uncalcified, radiating from the stipes to

the margin, subparallel, congested, pluriseriately arranged, the layers of filaments crossing obliquely, dichotomously but inconspicuously branched, normally unevenly constricted above the dichotomy, bearing numerous unilateral, short, simple or bifid (rarely trifid), sessile (rarely pedicellate), pointed appendages.

Filaments of stipes bearing lateral appendages, 2—4 times dichotomous and terminated by dactyline tapering acute apices, which are approximated together to form the cortex of the stipes. [Figs. 10, 11, 54].

The type of *U. Palmetta* Decne. is preserved in the Paris Herbarium (fig. 10), but there is no information to shew where the specimen was gathered. And since Decaisne gives none in his original description, there is unfortunately no clue as to the original home of the type. Decaisne's specimen was for some years the only representative of this species so far as we can ascertain. The home of *U. palmetta* remained therefore a mystery until the collections of Mr. Stanley Gardiner yielded fresh examples, which indicate without doubt that the original locality of the type was situated in the western Indian Ocean, possibly indeed at Galega Island. We have discussed this question in a paper in Trans. Linn. Soc. (Bot.) VII. 1908. p. 175.

The main filaments in the frond of *U. palmetta* are sometimes disposed in two layers only, but sometimes in as many as three to five layers.

The nearest ally of *U. palmetta* is *U. spinulosa* Howe, a West Indian species, which it resembles in having unilaterally situated, spinose appendages on its frond-filaments. It differs however from that species in having the frond-filaments about half as thick as in *U. spinulosa*, the lateral appendages usually sessile and simple or forked or trifid (rarely stalked and never pluri-spinose) (fig. 11), and the supra-dichotomial constrictions markedly uneven.

The West Indian *U. verticillosa* differs in having the lateral appendages disposed around the upper frond-filaments in dense subverticils (fig. 23 *a*).

U. indica has unilateral appendages on the superficial filaments of the frond; but they are short, blunt, peltate or truncate (fig. 53). As in that species and in *U. spinulosa*, so also in *U. palmetta*, the lateral appendages are situated only on the external surface of the superficial filaments, and function as "windows" (see pp. 5 and 103): they are absent from the inner surfaces where the filaments touch one another.

Decaisne's original description of *U. palmetta* in his Mémoire sur les Corallines (l. c.) was short and insufficient and omitted all mention of the lateral appendages of the filaments, though they had already been figured in his Classification des algues (l. c.) and mentioned in his short obscure note (l. c. p. 380) explanatory of the figure, where he describes the main filaments as "Cellules dentées, qui par leur enchevêtrement, constituent toute la "partie inférieure de la plante; dans leur premier age, ces cellules sont presque cylindriques". This passage and the figure seem to have been entirely overlooked. Consequently Kützing, J. G. Agardh and others, who have never examined the type-specimen, have failed to form a true conception of this species. They have confused it on the one hand with some Australian specimens which we include under *U. orientalis*, and on the other with a plant from the

Arabian Gulf (Red Sea) which Kützing figured (Tab. Phyc. VIII. 1858 tab. 27) under the name *Flabellaria Palmetta* and which we discuss under *U. explanata* (p. 121).

U. palmetta is, so far as we know, confined to the western Indian Ocean.

10. *Udotea spinulosa* Howe

n. Howe, Torrey Bot. Club XXXVI. 1909 p. 97, pl. IV, fig. 2; pl. VIII, figs. 1—7.

Syn. *Udotea spinulosa* Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 395.

Hab. Atlantic. Collected on a sandy bottom near low-water mark in Bemini Harbor, Bahamas, *Howe* n° 3272, April 17, 1904!

Also sine loco sub nomine "*U. conglutinata*" Chauvin MS. in *Herb. Caen*! — St. Jan, Danish West Indies, *Borgesen* n° 1915 pro parte and n° 2101 pro parte! — St. Thomas, 5—15 fathoms, "*Challenger*" Expedition, in Herb. Kew!

"Plants 7—8 cm. high, from a fusiform or fasciculate funicular rhizoidal base, grayish "green, strongly calcified: stipe simple, subterete below, flattened above, 1—2 cm. long, "3—4 mm. wide, corticated, its surface nearly smooth or minutely velutinous-tomentulose: "flabellum obovate with a subcuneate base, 5—6 cm. long, 4—6 cm. wide, 0.4—0.6 mm. thick, "longitudinally furrowed or striate, not at all or very faintly zonate, rather rigid and brittle "when dry, lateral margins subentire, apical margin more or less laciniate and commonly "fractured, the surface appearing minutely corrugated or spongiose-velutinous under a lens, "becoming compact and nearly smooth toward the base: filaments of the flabellum in 3—7 "layers, nearly parallel or flexuose and interwoven, subcylindrical, sparingly dichotomous, "strongly constricted just above the dichotomies, 46—84 μ in diameter, enclosed in a non-porose "calcareous sheath especially in the outer parts, or irregularly incrusted, the superficial (or the "interior wherever they touch the surface) thickly beset externally with short cylindrical, trun- "cate-conical, subturbinate or obconical processes 16—40 μ in diameter, each crowned with "2—8 acuminate prongs or spines formed by 1—3 close-set dichotomies, these lateral processes "(mostly 55—160 μ long, including their spinulose crowns) forming an imperfect kind of cortex: "medullary filaments of the stipe 70—110 μ in diameter, the lateral corticating branches 4—6 "times dichotomous, their ultimate divisions taper-pointed, 28—200 μ long and 8—24 μ in "median diameter". [Figs. 12, 55].

We give Dr. Howe's full description as published. The plant described and figured by Dr. Howe is unmistakeable (our fig. 55). We found a specimen of it seven years ago among Chauvin's algae preserved in the Caen Herbarium. That specimen is without locality, like Decaisne's *U. palmetta*, and has always been a mystery to us. There can be but little doubt now that Chauvin's plant came from the West Indies and probably from the Bahamas, like others of his calcified algae.

U. spinulosa differs from its nearest ally, *U. palmetta*, an Indian Ocean species, as Dr. Howe points out, "in the thicker (0.4—0.6 vs. 0.09—0.16 mm.), more rigid, less zonate "flabellum and its subcuneate base, by the larger (46—84 μ vs. 8—30 μ), less flattened fila- "ments, which are regularly and strongly constricted above the dichotomies, and by the character

"of their lateral appendages, which are closely 1—3 times dichotomous instead of simple or "once furcate and are 55—160 μ long instead of 11—30 μ long, the spines crowning a thick "stump-like base or pedestal instead of being practically sessile."

There is however a form in which the lateral appendages of the frond-filaments are very weakly developed, being much reduced in size, and disappearing altogether in the apical part of the filament; that is to say, the topmost 2—3 mm. of the filaments are entirely destitute of lateral appendages. For this form we propose the name

forma *palmettoidea*.

Syn. *Udotea conglutinata* Dickie in Journ. Linn. Soc. (Bot.) XIV. 1875. p. 312, pro parte.

Hab. ATLANTIC. St. Thomas 5—15 fathoms, "*Challenger*" Expedition in Herb. Kew!

Filaments of the frond bearing lateral appendages arranged secundly as in the type, but smaller (10 μ long), simple to trifid, and sessile above; below 2—3-fid, sometimes simple, 40—70 (sometimes up to 110) μ long, pedicellate; all acute; absent from the topmost 2—3 mm. of the filament. [Fig. 56].

The type in Kew Herbarium bears in DICKIE's MS. the name "*Udotea conglutinata*" and was published as such by him. It is the larger of two plants stuck on the same mount, the other plant being a specimen of our *U. verticillosa*.

Though f. *palmettoidea* differs much from the type of *U. spinulosa* in the weak development of its lateral appendages, it must not be confused with *U. palmetta*, an Indian Ocean species, which at first sight it broadly resembles. It is easily distinguished at once by its even supra-dichotomial constrictions (fig. 56), and by its 2—3-fid pedicellate lateral appendages. The supra-dichotomial constrictions of *U. palmetta* are uneven (as is the case in almost all East Indian species of *Udotea*) and the lateral appendages are simple or bifid (rarely trifid) and sessile (rarely shortly pedicellate).

Dr. BÖRGESEN collected in St. Jan (n° 2101 pro parte) a plant intermediate between the type and the f. *palmettoidea*.

The differences which distinguish *U. verticillosa* from *U. spinulosa* are given under the former species (p. 129).

The geographical distribution of *U. spinulosa* is confined to the Bahamas and the Danish West Indies.

11. *Udotea argentea* Zanardini

in Plant. Mar. Rubr. in Mem. R. Ist. Ven. vol. VII. 1858. p. 290. tab. X, figs. 1, 1a, 1b.

Syn. *Udotea argentea* J. G. Agardh Till Alg. Syst. V. 1889. p. 76.
Udotea argentea De Toni Syll. Algarum I. 1889. p. 511.
Udotea argentea A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908. p. 176; also op. cit. (Zool.) XII. 1909. p. 386.

forma *typica*:

Hab. INDIC. Red Sea, Suez, *Portier*. — Suez Bay, *Crossland*! — Seychelles, Coetivy reef, *J. Stanley Gardiner*! — Cargados Carajos, 22, 30, and 47 fathoms, *J. Stanley Gardiner*!

Siboga Expedition, Stat. 131. Karkaralong Islands, reef! — Stat. 133. Lirung, Salibabu Island, 30 m.!

PACIFIC. Queensland, *Bailey* in Herb. Mus. Brit.! — Dunk Island, Queensland, *Banfield*!

var. *spumosa* var. nov.

Hab. INDIE. *Siboga Expedition*. Stat. 64. Tanah Djampeah, 30 m. n° 273! — Stat. 96. Pearl Bank, Sulu Archipelago, 15 m.! — Stat. 213. Saleyer, reef!

Plants varying in length, reaching about 15 cm. in height, much calcified. Root-mass balbous to elongate. Stipes simple, usually short and thick.

Frond varying from simple, subreniform-flabellate to repeatedly, abundantly and remarkably proliferous, sometimes zoned; usually longitudinally striato-plicate; ashy-green, the surface varying from smooth to minutely spumose or polyporoid in appearance; margin entire, erose or lobate.

Main filaments of frond 40—60 μ in diameter, parallel, not contiguous, distromatic to pluriseriate, sparingly dichotomous, very unevenly constricted above each dichotomy, bearing distichously numerous short lateral branchlets of nearly equal length (about 100—180 μ in length), each constricted above the base and bearing an inflated pyriform simple or more or less lobed head: such heads contiguous, forming a cortex, concealing the main filaments.

Filaments of stipes bearing long branchlets (0.5—1.0 mm.), 1—4 times dichotomously branched, with very obtuse apices. (Figs. 15, 21, 22*c*, 22*d*, 25*a*, 57—62).

forma *typica*.

Plant 3—10 cm. high. Frond subreniform-flabellate to rotundate, sometimes very proliferous: surface very minutely and obscurely cellular to indistinctly spumose (rarely distinctly spumose or polyporoid). Frond-filaments 40—60 μ in diameter, bearing lateral capitate branchlets, with head distinctly and variously 2—6-lobed, sometimes embossed with 2—9 rounded prominences, sometimes complanately flattened and subpalmately lobed. (Figs. 21, 22*c*, 22*d*, 57—60).

var. *spumosa*.

Plant up to 15 cm. high, 23 cm. wide, with proliferations widely overlapping: surface distinctly spumose or polyporoid. Frond-filaments 40—60 μ in diameter, bearing elongate-pyriform lateral branchlets, usually simple, with apex rounded (in lower part of frond) or flattened or depressed (in upper part of frond). (Figs. 15, 25*a*, 61, 62).

The identity of this species was not at first easy to determine, owing to the disappearance of ZANARDINI's type. All efforts to trace this have failed, although Dr. JOHN BRIQUET has most kindly searched the Delessert Herbarium in Geneva which contains many of ZANARDINI's plants, and Prof. DE TONI has also tried to trace the plant in Italy. In default then of anything better, we have been compelled to depend almost entirely on ZANARDINI's description and plate (loc. cit.), and fortunately the figure of the internal structure is sufficiently good to enable the identity of plants in the Siboga and other collections to be determined. Indeed, we were able to do this satisfactorily and to separate off var. *spumosa* five years before we had the good fortune to see any specimen of *D. argentea* from the Red Sea. Recently through

the kindness of Prof. R. J. Harvey Gibson we have had the privilege of examining a specimen from the type-locality.

The main characteristic of *U. argentea* lies in the position and form of the lateral appendages, which are close together, short and of approximately equal length, having either a simple and inflated (figs. 61, 62), or a lobed (figs. 58—60), head. The proximity of the branchlets causes the heads to be appressed against each other above and thus to form a closed pseudo-cortex covering the main filaments.

The lateral appendages of the frond-filaments of *U. argentea* exhibit sufficient variability in different specimens to suggest a separation of the plants into two groups. The typical form is found in the Red Sea and the Indian Ocean (fig. 57), and as far east as the coast of Queensland. Its lateral appendages bear each a distinctly and variously lobed capitulum, which is inflated and adorned with a few low bosses, as in specimens from Cargados (see figs. 58 *a*, 58 *c* and 59) and Queensland; or complanately flattened and subpalmately lobed as in the Lirung specimens, (see figs. 58 *b* and 60). The Karkaralong specimens of the Siboga Expedition bear appendages of both these kinds, and also here and there show groups of appendages almost as simple as those of var. *spumosa* (see fig. 22 *c*).

The var. *spumosa* (fig. 15) occurs only in the eastern Indian Ocean and is distinguished from the type by the simple elongate pyriform capitulum (figs. 61, 62), which terminates each of its lateral appendages. The surface of the frond is minutely spumose or polyporoid; but this character is also shared by some of the plants of f. *typica*.

The nearest ally of *U. argentea* is *U. occidentalis*, a species confined to the West Indies and distinguished by its narrower frond-filaments with shorter lateral appendages (not or rarely exceeding 100 μ in length), the capitula of which are more divided and are adorned with more numerous and smaller prominences.

Inasmuch as the branchlets in *U. argentea* abut against one another and are not intricated, they are easily teased apart after decalcification, and are thus in marked contrast to the lateral appendages of *U. flabellum*, which are so much interlocked that it is almost impossible to separate them without tearing them.

U. argentea occurs in the Indian and Pacific Oceans.

12. *Udotea occidentalis* n. sp.

Syn. *Udotea Halimeda* Dickie in Journ. Linn. Soc. (Bot.) XIV. 1875 p. 312.
Udotea flabellata Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Udotea Halimeda Murray op. cit. p. 239.
Udotea argentea Howe in Bull. Torrey Bot. Club. XXXVI. 1909. p. 99.
Udotea argentea Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 396.

Hab. Atlanic. West Indies, St. Thomas, 5—15 fathoms, "*Challenger*" Expedition, (sub. nom. "*U. Halimeda*") in Herb. Mus. Brit.! — St. Jan, *F. Börgesen*, herb. nos 1767, 2101, and an unnumbered specimen! — West Indies, *Fleming* in Herb. Mus. Brit.!

Plants up to 8 cm. high, much calcified. Root-mass small, bulbous, fibrous. Stipes simple, terete, short (up to 1 cm. long), slender (1.5 mm. thick).

Frond ashy grey below, green above, from a cuneate base obovate, more or less proliferous, zoned, faintly striate, surface very minutely and obscurely cellular.

Frond filaments 30—15 μ in diameter, approximated, rarely contiguous, pluriseriate, bearing lateral capitate branchlets about 70—120 μ long (occasionally up to 180 μ at base of frond) with head simple or divided lobately, inflated and embossed with 6—20 low rounded prominences (forming "windows" in the incrustation; see p. 103); supra-dichotomial constrictions uneven.

Filaments of stipes bearing long-stalked lateral appendages, each 2—3 times dichotomous above and then subdivided shortly and irregularly, terminating in numerous abbreviated obtusely rounded apices. [Figs. 18, 22 *a*, 22 *b*, 63—65].

U. occidentalis (figs. 63, 64) is so closely allied to *U. argentea* that we long regarded it as only a variety of that species, but we now feel that it is specifically distinct. Not only is its distribution widely different from that of *U. argentea*, but it presents differences of structure both characteristic and constant. The frond-filaments are always narrower in diameter, and their lateral appendages always shorter, bearing capitula more divided and almost botryoidally lobulate (figs. 22 *a*, 22 *b*).

The type of this species was collected by the "Challenger" Expedition and is in the British Museum (fig. 63). It is destitute of a stipes, as also are the two other specimens mounted with it. Possibly all three may be unusually large proliferations torn off the primary plant by the dredge: or on the other hand they may be three distinct fronds severed from their stalks in the same way. Dr. FLEMING's plant is stipitate and very proliferous: it came from an unknown locality in the West Indies. We have recently seen three other complete specimens of *U. occidentalis*: they were collected at St. Jan by Dr. F. BÖRGESEN: and one of them we have figured (fig. 64).

The average size of the plants is smaller than that of *U. argentea*. The tendency to proliferation, which is possibly due to injury or other external influences, is a striking feature common to all the complete specimens that we have seen.

The distribution of *U. occidentalis* appears to be very limited, being confined to the Danish West Indies, so far as is shown by our material.

13. *Udotea verticillosa* A. & E. S. Gepp

in Journal of Botany vol. XLVII. 1909. p. 269.

Syn. *Udotea conglutinata* Dickie in Journ. Linn. Soc. (Bot.) XIV. 1875 p. 312, pro parte.
Udotea flabellata Dickie loc. cit.
Udotea conglutinata Murray in Journ. of Bot. XXVII. 1889. p. 238 (pro parte).
Udotea flabellata Murray loc. cit. (pro parte).

Hab. ATLANTIC. West Indies, St. Thomas, 5—15 fathoms, "*Challenger*" Expedition, in Herb. Mus. Brit.! and Herb. Kew! — St. Thomas, *F. Börgesen*, herb. nos 1019 (15 fathoms)!, 1137 (20 fathoms)!, 1173 (15 fathoms)!, — St. Jan, *F. Börgesen*, herb. nos 1767!, 1823!, 1875a (15 fathoms)!, 1915!, 2101!, 2211!, 2248!

Plant about 10 cm. high, calcified, stipitate. Stipes simple, up to about 4 cm. (usually only 1.5 cm.) long, 1 mm. thick, apex sometimes flattened out and cuneate.

Frond from a usually cordate (rarely cuneate) base flabelliform, up to about 10 cm. wide, proliferous from margin (proliferation sometimes abundant and imbricate), sometimes striate, usually distinctly zonate; colour greyish-green. Surface very minutely crustato-spiculose or granulose.

Frond-filaments 30—60 μ in diameter, parallel, not contiguous, monostromatic at apex to pluriseriate below, sparingly dichotomous, without evident supra-dichotomial constrictions, bearing subsessile or shortly stalked 2—4-furcate, or long and simple, lateral appendages, arranged in close, opposite or alternate or secund, semiverticils, or more laxly and irregularly distributed around the filament. Lateral appendages acute, rather irregularly arranged in lower part of frond, being often interruptedly distichous and secund, pedicellate and varying in length (30 μ—180 μ); in upper part of frond fairly regular in arrangement and size (40—90 μ simple, 30—50 μ coronate), originating quite close up to the growing apices of the main filaments and speedily attaining the normal shape.

Stipes-filaments bearing lateral appendages 170—350 μ long, consisting of a stout pedicel 2—4 times dichotomous above and terminating in acute prongs. [Figs. 16, 19, 23, 25*b*, 25*c*].

The description of *U. verticillosa* published in the Journal of Botany (loc. cit.) now somewhat expanded, was founded on two specimens collected at the island of St. Thomas in the West Indies by the "Challenger" Expedition and preserved in the British Museum (fig. 16). More recently we have had the privilege of examining numerous examples of this species collected by Dr. Börgesen in the Danish West Indies. A study of these has given us a satisfactory confirmation of the validity of our species, and at the same time has shown us in what details of structure it is liable to vary — namely, the shape and arrangement of the lateral appendages (fig. 23). This variability is indeed one of the remarkable features of the present species. In the same plant and indeed on one and the same frond-filament, the lateral appendages may vary from 2—4-furcate to simple, may be sessile or stalked, varying in length, arranged in opposite, alternate or secund semiverticils, or irregularly scattered. It is not easy to indicate any one precise characteristic of structure applicable to the whole frond, by which the species may always be indisputably distinguished. The best guide is to be found in the usually subverticillose arrangement of the acute lateral appendages in the upper, especially the apical, part of the frond, and in the fact that these appendages are found to be strongly developed quite close up to the growing apices of the main filaments of the frond.

The nearest allies are on the one hand *U. Wilsoni*, which resembles it in the verticillose arrangement of its lateral appendages (fig. 67), but differs in the fact that these are always obtuse and never acute; and on the other hand *U. spinulosa* which resembles it in a certain degree by having acute-pointed, bi- to pluri-spinose, sessile or pedicellate lateral appendages, but differs in the fact that these are secund (fig. 12), and almost always are monostichously secund, and never in any way verticillate. Moreover the main filaments of the frond show distinct supra-dichotomial constrictions in *U. spinulosa*, and none in *U. verticillosa* (fig. 23*a*).

U. verticillosa is readily distinguished from *U. occidentalis* and *U. argentea* in having the lateral appendages of its main filaments arranged in close subverticils, many-pronged and acute, not capitate nor longly pedicellate.

In respect of the character of their frond filaments *U. verticillosa* and *U. Wilsoni* form a group which seems related to *U. papillosa* (p. 112). The rationale of the lateral appendages in *U. verticillosa* appears to be as follows:

1. In the apical part of the frond the main filaments are monostromatically arranged, and the lateral appendages, being generated close up to the apices of the filaments, are produced in opposite pairs on the front and back of the frond. If the main filaments be not closely contiguous, then between them is left room for the lateral appendages to spread round towards the sides of the filament and to assume the appearance of investing verticils.

2. At the base of the frond the main filaments are pluriseriate (apparently from the very first) and correspondingly the lateral appendages exhibit a different arrangement. These are secund for the most part, being situated on that side of the filament which is nearest to the surface of the frond. They are sessile when arising from a superficial filament; and when arising from the deeper filaments have pedicels of sufficient length to enable them to reach the surface of the frond.

Sometimes they are monostichously arranged, recalling the appearance of *U. spinulosa*; sometimes they are arranged in two rows near together, like the legs of a caterpillar. In *U. verticillosa* supra-dichotomial constrictions are absent (fig. 23 *a*), being either masked by the exuberant growth of the lateral appendages, or never allowed time to form owing to the prepotent development of the lateral appendages close up to the very apices of the growing filaments.

Reference was made above to the close affinity existing between the group of *U. verticillosa* and *U. Wilsoni* (both West Indian species) and the more primitive (East Indian) species *U. papillosa*. In this latter, opposite papillae occur front and back on its monostromatically arranged upper filaments; while on the lower and basal filaments the papillae are arranged in double pairs and even in verticils. They are simple, acute or obtuse; rarely, at the base of a frond, they are forked.

U. verticillosa is confined to the Danish West Indies.

14. *Udotea Wilsoni* Gepp and Howe n. sp.

Hab. ATLANTIC. Bahamas, Anguilla Isles, Salt Key Bank, North End, *P. Wilson.* Howe n° 7968!

Plant about 10 cm. high, more or less calcified, stipitate. Stipes up to 4 cm. (usually 1—1.5 cm.) long, simple or branched above, branches free or cemented together.

Frond composed of a laminated mass of numerous flabellate proliferations arising from one another superficially, and for the most part arising from a position near and parallel to the central axis of the mass (i. e. an imaginary prolongation of the stipes upwards). Individual fronds generally semi-cordate at base, semi-rotundate above or semi-flabellate, entire or lobed, striate, sometimes zonate, greyish-green with flavescent margins when young, cinerascent when old. Surface very minutely spongiose or granulose.

Frond-filaments 40—50 μ in diameter, subparallel, mixed with flexuose intricating branches, pluriseriate, sparingly dichotomous, without evident supra-dichotomial constrictions, thickly beset with short, simple or forked, very obtuse lateral appendages. Lateral appendages for the most

part arranged in two double rows directed towards the front and back surfaces of the frond, about 25—40 μ long, in upper part of frond; in lower part of frond less regular in arrangement and size, being usually distichously secund and interrupted, about 25—120 μ long.

Filaments of stipes bearing lateral appendages one or more times dichotomously divided and with obtuse apices. [Figs. 66—68].

U. Wilsoni is an interesting addition to the genus and forms with its near ally, *U. verticillosa*, a little group characterised by the crowded pseudo-verticillose arrangement of the lateral appendages of, and by the absence of supra-dichotomial constrictions from, the main filaments of the frond. The most obvious difference between the two species is that the lateral appendages in *U. Wilsoni* are very obtuse (fig. 67), while in *U. verticillosa* they are acute.

The specimens of *U. Wilsoni* submitted to us by Dr. Howe are all compound (fig. 66), consisting not of a simple stipitate flabellum, but of a laminated mass or a congeries of flabella hinged, as it were, upon an imaginary axis forming an upward prolongation of the stipes. Possibly this peculiar habit may be due to the conditions under which these plants were found growing. We have no data as to their environment, save that they were plentiful in shallow, sandy bays (P. Wilson in Journ. New York Bot. Garden. X. 1909 p. 175).

We are indebted to Dr. Howe for permission to describe this species, the material of which was communicated to him by Mr. P. Wilson the finder, after whom it is named.

U. Wilsoni it at present only known from the Bahamas.

15. *Udotea flabellum* Howe

in Bull. Torrey Bot. Club. XXXI. 1904. p. 94.

Syn. *Corallina Flabellum* Ellis & Solander Nat. Hist. Zoophyt. 1786. p. 124. tab. 24.
Corallina Flabellum Gmelin Linn. Syst. Nat. vol. I. part VI. 1790. p. 3842.
Corallina Pavonia Esper Fortsetzung der Pflanzenthiere. II. Theil. 1798—1806. tabs. 8, 9 (no text).
Corallina Flabellum Bosc Hist. Nat. des Vers (Suites à Buffon) vol. III. 18mo Paris (Déterville). 1802. p. 71.
Flabellaria Pavonia Lamarck Polyp. empâtés in Ann. Mus. d'Hist. Nat. tom. 20. 1813. p. 301.
Udotea flabellata Lamouroux Hist. Polyp. corall. flex. 1816. p. 311, tab. XII, fig. 1.
Flabellaria Pavonia Lamarck Hist. Nat. Animaux sans vertèbres. tom. II. 1816 p. 343. n° 2; op. cit. ed. II. tom. II. 1836. p. 527.
Corallina flabellum Cuvier Règne Animal IV. 1817 p. 77.
Udotea flabellata Lamouroux Expos. méth. 1821. p. 27. tab. 24.
Udotea flabellata Deslongchamps in Encyclop. Méth. Zoophyt. 1824—5. p. 762.
Udotea flabelliformis Blainville in Dict. Nat. LVI. 1828. p. 229.
Udotea flabellata Decaisne Mém. s. l. Corallines etc. in Ann. Sci. Nat. vol. XVIII. 1842. p. 105.
Udotea Pavonia Decaisne op. cit. p. 107.
Flabellaria incrustata Chauvin Recherches 1842. p. 123.
Udotea flabellata Kützing Species Algarum 1849. p. 502.
Udotea Halimeda Kützing op. cit. p. 503.
Udotea flabelliformis Duchassaing Animaux Radiaires des Antilles. Paris. 1850. p. 29.
Udotea flabellata Kützing Tab. Phyc. vol. VII. 1857. p. 8. tab. 20.
? *Udotea Halimeda* Kützing loc. cit. vol. VIII. 1858. p. 11. tab. 26, figs. II. a & b.
Udotea flabellata Harvey Nereis Bor. Amer. vol. III. 1858. p. 26.

Udotea flabellata Mont. & Schramm Alg. Guadeloupe ed. II. 1870—77. p. 88.
Udotea flabellata Farlow in Proc. Amer. Acad. X. 1875. p. 377, and U. S. Fish Comm. Report. III. 1876. p. 711.
Udotea flabellata Sonder in F. von Mueller's Fragm. Phytogr. Austral. XI. Suppl. 1880. p. 38.
Udotea flabellata J. G. Agardh Till Alg. Syst. V. 1887. p. 75.
Udotea flabellata Murray in Journal of Bot. XXVII. 1889. p. 238 (pro parte).
Udotea flabellata De Toni Syll. Algarum vol. I. 1889. p. 510.
Udotea flabellata Collins Green Alg. N. Amer. in Tufts College Studies II. 1909. p. 395.

HAB. ATLANTIC. — Bahamas, *Catesby* in Herb. Sloane vol. 232, fol. 16 and 18! — Among "Plants & Submarines gathered at Carolina, Bermuda & the Caribbees by the Rev. Mr. *Clerk*" in Herb. Sloane vol. 318, fol. 48, nos 9 and 10! — Bermuda, *Farlow*! — Bermuda, Hungry Bay, *Howe* n° 183! — Bermuda, Ponds of Walsingham, *Howe* nos 120 and 203! — Bermuda, "*Challenger*" *Expedition*! — Florida, Key West, *Ashmead*! *Herb. Farlow*! *Messina* in Phyc. Bor. Amer. n° 472! — Florida, near Lake Worth Inlet, *Curtiss*! — Cuba, *Wright*! — Jamaica, *Sloane* in Herb. Sloane vol. I. fol. 20! — Jamaica, *F. S. Collins*! — Jamaica, Port Antonio, *C. F. Pease & E. Butler*! — St. Croix, *Herb. Kutzing*! *Herb. Dickie*! *F. Borgesen* in Wittrock et Nordstedt Alg. Exsicc. n° 1202! also *Herb. Borgesen*, nos 1305, 1385, 1439, 1480, 1503, 1672a, 1705! — St Thomas, *Herb. Borgesen*, nos 1137a (20 fathoms), 1173 (15 fathoms), 2243! — St Jan, *Herb. Borgesen*, nos 1729, 1763 (15 fathoms), 1822, 1875 (15 fathoms), 2084 (10 fathoms), 2174 (15 fathoms), 2195! — Porto Rico, Fajardo, *Sintenis* n° 28! — Porto Rico, Guanica, *Sintenis* n° 76! — Guadeloupe, *Mazé*, nos 93 and 886! — Grenada, Bay of Clarke's Court, *Murray*! — Grenada, Morne Rouge Bay, *Murray*! — Antilles, *Herb. Shuttleworth*! — British Honduras, *Mrs. Mitchell*, in Herb. Kew!

INDIC. Red Sea, *Lord Valentia*! — Ceylon, *Koenig*!, *Ferguson*, n° 420! — Madras, *Thurston*! — Tuticorin, *Thurston*! *Wight*!

Siboga Expedition. Stat. 43. Pulu Sarasa, Postillon Islands, nos 173! 174! — Stat. 71. Macassar, Pulu Barang, shore! — Stat. 78. Lumu-Lumu-shoal, Borneo bank, reef! — Stat. 79. Kabala dua, Borneo bank, reef! — Stat. 99. North Ubian, Sulu Archipelago, 18 m.! — Stat. 133. Lirung, Salibabu Island, reef!

PACIFIC. Ooleva, Friendly Islands, *Harvey* n° 94! — Port Curtis, Queensland, *Macleay* in Herb. Kew! — Dunk Island, Queensland, *Banfield*, in Herb. Kew! — Cooktown, Queensland, *fide Sonder*.

Plants varying in length to about 21 cm., as a rule thickly calcified. Root-mass bulbous to elongate. Stipes simple, varying to 15 mm. long, and 5 mm. thick, flattened above.

Frond stalked, very variable in form, from a cuneate base usually suborbicular-flabelliform, simple at first, becoming repeatedly and irregularly proliferous from the margin and sometimes from the surface, zoned, often striate or plicate; proliferations broad or narrow, frequently abundant and overlapping, repeating the character of the main frond; varying in colour from green to greenish-white or greenish-brown; usually solidly calcified, smooth to rugose; margin entire, or more or less lobed.

Frond-filaments more or less parallel, radiating upwards, pluriseriate, separated, not contiguous, sparingly dichotomous, without supra-dichotomial constrictions, bearing lateral branchlets of unequal length, at irregular intervals, cylindrical or sometimes thinner above the base, densely and fasciculately or cymoidly branched above. Apices of lateral appendages obtuse, dactyline or truncate-capitate, contiguous, combining to form a tough close cortex.

Filaments of stipes bearing lateral appendages resembling those of the frond, but in every respect laxer. Fig. 26—28.

This species, the *Corallina flabellum* figured by Ellis and Solander (loc. cit.) in 1786 enters largely into the early history of the genus *Udotea* (see p. 99).

U. flabellum (fig. 26) is a very variable species as regards outward form, being either simple and suborbicular with entire margin, or repeatedly and irregularly proliferous with a more or less lobed margin. Any variation may occur between these extremes. An examination of the internal structure however reveals at once the identity of the plant, for the lateral appendages occur at irregular intervals (fig. 27) and are of unequal length, while the dense and irregular subdivisions of their apices (fig. 27 *b*) are so closely interlocked that it is difficult, even after decalcification, to disentangle them without tearing them. A comparison between the lateral appendages of *U. flabellum* and *U. argentea* shews that those of *U. flabellum* are longer and more irregularly situated than those of *U. argentea*, and the apices of the lateral appendages are quite different in their form, those of *U. flabellum* being dichotomously subdivided (fig. 27 *b*), and more or less cymoidly compound (fig. 27 *a*), while those of *U. argentea* are either quite simple and pyriform (fig. 61), or once or twice divided, lobulate, inflated and often embossed.

U. flabellum is widely distributed in the tropical zone of both east and west hemispheres, and, variable as it is in external form, it is at once recognisable in respect of its solid smooth-looking superficial incrustation and of its internal structure, namely the spaced-out pluriseriate main filaments with irregularly disposed lateral appendages of unequal length. The eastern plants however, as compared with the western, sometimes shew a difference in the cymoid ramification of the lateral appendages of the frond, the apices being truncato-capitate and not so dactyline as in the majority of the western plants. The differences are however not sufficiently definite or stable to enable us to separate the eastern plants as a distinct form.

In the British Museum is a queer specimen collected by Dr. M. A. Howe in the ponds of Walsingham, Bermuda, which have subterranean communication with the sea. It is remarkable for its narrow elongate habit and linear proliferations; probably due to insufficient illumination, and not to a modification of the sea-water, since Dr. Howe's other specimen from the same locality has comparatively broad proliferations.

In the list of synonomy for *U. flabellum* we have placed the name *U. Halimeda* Kützing. This species was described by Kützing in his Species Algarum p. 503 and the locality given as "Bahia (v. s. in coll. Binder)". The original plant described has been most kindly lent to us for examination by Major Reinbold and shews the internal structure and external form of *U. flabellum*. The plants from the Bahamas however, which are figured in Kützing's Tab. Phyc. VIII. tab. 26. fig. II *a* and *b*, under the same name of *U. Halimeda* are more markedly proliferous than the Bahia specimen [they resemble in outward form the Siboga plants of *U. argentea* var. *spumosa* (see our fig. 15)]. It has not been possible to trace these Bahama plants. And hence their internal structure is unknown to us.

U. flabellum occurs in all oceans within the tropical limits, and is remarkable as being the only species of the Codiaceae (apart from a few species of *Halimeda* and *Codium*) which is found in both hemispheres, East and West.

APPENDIX

SPECIES OF **CODIUM** COLLECTED

BY THE

SIBOGA EXPEDITION

1. *Codium adhaerens* Agardh

Spec. Alg. I. 1823. p. 457.

Stat. 16. Kangeang Island.
Stat. 53. Nangamessi, Sumba Island.
Stat. 60. Haingsisi, Samau Island, Timor.
Stat. 89. Kaniungan-ketjil, Celebes Sea.
Stat. 131. Beo, Karakelang Islands.
Stat. 133. Lirung, Salibabu Island.
Stat. 165. Daram, East coast of Misool.
Stat. 205. Buton Strait, drifting.
Stat. 220. Binongka Island.
Stat. 250. Kur Island, reef.
Stat. 252. Taam Island, reef.

Also specimens from Shoal "de Bril" near Macassar and from Bira, Celebes leg. A. WEBER VAN BOSSE.

2. *Codium difforme* Kützing

Phyc. gen. 1843. p. 309; and Tab. Phyc. VI. 1856. p. 35. tab. 99. fig. II. — Bornet Algues de Schousboe in Mem. Soc. Sci. Cherbourg XXVIII. 1892. p. 215.

Stat. 99. North Ubian, Sulu Archipelago.
Stat. 205. Buton Strait.

3. *Codium ovale* Zanardini

in Nuov. Giorn. Bot. Ital. X. 1878. p. 37.

Stat. 93. Sanguisiapo, Tawi-Tawi Islands, Sulu Archipelago.
Stat. 96. Pearl Bank, Sulu Archipelago, Lithothamnion bottom.
Stat. 99. North Ubian, Sulu Archipelago, 16 m.

Stat. 133. Lirung, Salibabu Island, reef.
Stat. 144. North of Salomakiče (Damar) Island.
Stat. 152. Bay of Wunoh, Waigëu.
Stat. 240. Banda, 27 m.
Stat. 301. Pepela Bay, Rotti Island, reef.
Stat. 315. Sailus Besar, Paternoster Islands.

4. *Codium petaloideum* n. sp.

Hab. INDIC. *Siboga Expedition.* Stat. 81. Sabangkatan, Borneo bank, reef: dried and in alcohol.

Plant small, bright green, 10—12 mm. in height, 5—7 mm. wide, complanate, obovate, subsessile. Utricles of the external stratum subpyriform, obtusely rounded above, but often a little impressed, small, 180—240 μ long, 115—180 μ wide, thin-walled at apex. [Figs. 193, 194].

This species is distinguished from all other species of the genus by its small size (fig. 193), combined with its compressed shape and small pyriform utricles. The utricles (fig. 194) most nearly resemble those of *C. tenue* and *C. Muelleri* in shape, but are about one half as long as those of *C. tenue* and about one third to one half as long as those of *C. Muelleri*. And both those species are quite distinct in habit, being filiform. *C. petaloidea* might be mistaken for dried, flattened specimens of *C. ovale*, but an examination of their respective utricles reveals at once that *C. ovale* is characterised by much larger utricles, nearly 1000 μ in length, and 200 μ in width, and almost cylindric in shape. The new species is represented by four specimens only, one of which is preserved in alcohol.

5. *Codium tomentosum* Stackhouse

Nereis Britann. 1801. p. XXIV. — Ag. Spec. Alg. I. 1823. p. 452.

Stat. 43. Sarasa, Postillon Islands.
Stat. 47. Bima, entrance of bay.
Stat. 60. Haingsisi, Samau Island near Timor.
Stat. 79^{b}. Kabala Dua, Borneo bank.
Stat. 89. Kaniungan-ketjil, Celebes Sea.
Stat. 129. Karkaralong Islands, reef.
Stat. 131. Karakelang Islands.
Stat. 169. Atjatuning, West coast of New Guinea.
Stat. 172. Gisser Island, reef.
Stat. 213. Saleyer and South Island, reef.
Stat. 215. Kabia Island, Banda Sea, reef. n^{0} 410.
Stat. 240. Banda, 27 m.
Stat. 258. Tual, Kei Islands, reef.
Stat. 261. Elat, Great Key.
Stat. 272. Dobo, Aru Islands, reef.
Stat. 273. Jedan Islands, Aru Islands, 13 m.
Stat. 282. East Point of Timor, reef.
Stat. 299. Buka Bay, Rotti.
Stat. 313. Saleh Bay, Sumbawa Island.

There are also specimens from Anjer, Strait Sunda, VORDERMAN leg. and from Stations 272 and 273, which though flattened should, we think, be included under this species.

6. *Codium divaricatum* n. sp.

Hab. Indic *Siboga* Expedition Stat. 201. Flat, Great Key, reef' (with sporangia). — Stat. 260. Near Great Key, 30 m.' — Stat. 115. Kwandang Bay, Celebes, reef, on *Galaxaura lapidescens*!

Thallus procumbent, creeping, attached by rhizoids here and there, forming patches about 8 cm. wide, much and divaricato dichotomously branched, slender throughout, 1.5—0.5 mm. thick when dry, branches laxly intricate. Utricles of external stratum obovato-clavate to subpyriform, small 38—56 μ in length and 96—200 μ wide, thin-walled all round. (Figs. 195—199).

The nearest allies of *C. divaricatum* (figs. 195, 196) appear to be *C. repens* Crouan ex Vickers in Ann. Sci. Nat. ser. IX. vol. I (1905) p. 56, a Guadeloupe species, and *C. tenue* Kütz. from the Indian Ocean. It resembles *C. repens* in habit, ramification, and dimensions, but differs in the shape of its peripheral utricles (figs. 197, 198), which are short, broad, and pyriform, while those of *C. repens* are longer, narrow and clavate, resembling those of *C. tomentosum*. Moreover *C. repens* is recorded only from the West Indies.

Our plant resembles *C. tenue* in its slender habit, but differs from it in having a more bushy ramification and in the shape of the utricles which are pyriform and only about half as wide as those of *C. tenue*. In *C. tenue* the utricles are turbinate and often truncate above.

The rhizoids or filamentous organs of attachment arise from the filaments composing the medulla of the plant, and passing through the zone of peripheral utricles (fig. 198) expand into a terminal sucker (fig. 199).

7. *Codium tenue* Kützing

Tab. Phyc. VI. 1856. p. 33. tab. 95.

Stat. 99. North Ubian, Sulu Archipelago, 16 m.

8. *Codium elongatum* Agardh

Spec. Algarum I. 1823. p. 454.

Stat. 96. Pearl Bank, Sulu Archipelago.
Stat. 176. Misool Island, reef.

APPENDIX II

CONTAINING

LATIN DESCRIPTIONS OF NEW GENERA AND SPECIES.

According to Article 36 of the second International Congress of Botanists held at Vienna in 1905, it is requisite that the diagnoses of new plants should be published in Latin. The novelties in the preceding pages have been described in English; and in order to safe-guard their priority and ensure their validity it seems advisable to render their diagnoses into Latin.

Flabellarieae.

p. 16. *Chlorodesmis Hildebrandtii* n. sp.

Syn. *Chlorodesmis comosa* Hauck in Hedwigia XXVII. 1888. p. 92.
Chlorodesmis caespitosa Murray & Boodle in Journal of Botany XXVII. 1889. p. 71 pro parte.

Hab. in oceano indico ad ins. Comoro, leg. Hildebrandt!

Plantae circa 6 cm. altae gregariae caespitosae ad basim parvam intertextae, flavescenti-virides, filamentis inferne decumbentibus pallidis irregulariter ramosissimis, stolones laterales et rhizoides emittentibus; filamentis supra ascendentibus viridibus cylindricis rectis flaccidis usque ad 6 cm. longis, 80—130 μ crassis, per dichotomias remotas divisis, constrictionibus supradichotomialibus symmetricis. [Figs. 74, 75].

p. 33. *Avrainvillea clavatiramea* n. sp.

Hab. in oceano indico ad litus australe Novae Hollandiae ad "Port Phillip", leg. J. B. Wilson!

Planta e viridi brunnea, usque ad 14 cm. alta, solitaria; stipite circa 3.5 cm. longo, e basi parva tumida orto, superne in frondem flabelliformem, rotundatam vel apice prolificantem, usque ad 7.5 cm. longam et 8 cm. latam, inferne crassam, ad marginem superum membranaceam viridem saepe zonatam, cuneatim expanso; frondis filamentis flavido-brunneis majusculis, plerumque 35—55 μ crassis, strictiusculis, versus apices subclavatos obtusos saepe torulosis. [Figs. 92, 93].

p. 33. *Acrainvillea Ridleyi* n. sp.

Syn. *A. lacerata* A. & E. S. Gepp in Journal of Botany XLIII. 1905. p. 339.

Hab. in oceano indico, ad "Christmas Island", leg. H. N. Ridley! C. W. Andrews!.

Planta brunnea, circa 5 cm. alta, irregulariter ramosa, lobis e basi duriori ortis, 2.5—4.5 cm. longis, spongiosis, congregatis, saepe concrescentibus, plerumque stipitatis, superne cuneatim incrassatis, fasciculatis, difformibus, hic illic divisis; flabellis veris vel nullis vel erosis; frondis filamentis 25—35 μ crassis, plerumque torulosis, interdum filamentis cylindricis commixtis, pallide brunneolis hic illic densius brunneis; ramulis ultimis nonnunquam subclavatis. [Figs. 94, 96].

p. 34. *Acrainvillea canariensis* n. sp.

Syn. *Udotea tomentosa* Vickers in Ann. Sci. Nat. 8e sér. tom. IV. 1896. p. 300.

Hab. ad "Gran Canaria, Las Palmas", leg. Domina A. Vickers!

Planta brunneo-viridis, circa 12 cm. alta, solitaria, stipitata; stipite 5—6 cm. longo simplici compresso, superne in frondem rotundatam magnam, 6—9 cm. longam, 7—11 cm. latam, inconspicue zonatam, tenuem, margine subintegram fimbriatam vel parum laceratam, cuneatim expanso; frondis filamentis cylindricis, hic illic torulosis, versus apices haud decrescentibus haud clavatis, e viridi fulvo-brunneis, siccitate saepe collapsis, filamentis (ubi materie colorata farcta sunt) plerumque 30—40 μ diam. [Figs. 97, 98].

p. 35. *Acrainvillea Elliottii* n. sp.

Syn. *Acrainvillea sordida* Murray & Boodle in Journ. of Botany XXVII. 1889 p. 70 (quoad specimen "Grenada, Murray".)
Acrainvillea sordida Murray in Journ. of Bot. XXVII. 1889. p. 238. (pro parte).
Acrainvillea sordida De Toni Syll. Alg. I. 1889. p. 514. (pro parte).

Hab. in oceano atlantico ad Antillas "Grenada", leg. W. R. Elliott!

Planta (in alcohol conservata) brunnea, 6—13 cm. alta, quasi solitaria, rhizomate recto circa 5 cm. longo, 1 cm. crasso, interdum uno duobusve tumoribus lateralibus instructo, superne in stipitem 1—4 cm. longum, 0.6—1 cm. crassum, parum compressum simplicem, superne in frondem subito expansum, continuato. Frons e basi truncata late flabelliformis in plantis junioribus, sed in senioribus satis irregularis, brevis (3.5—5 cm.) lata (5—10 cm.) superne erosa lobata, interdum fere ad basim fissa, modice crassa, zonata, superficie minute rugosa (lobis interdum divaricatis et continenter crescentibus). Frondis filamenta cylindrica, tum parum torulosa, saepe brunneo-flava, parva (20—30 μ crassa, ad apices juveniles raro 15 μ) apicibus haud praecipue ramosis haud decrescentibus. [Figs. 99, 100].

p. 37. *Acrainvillea pacifica* n. sp.

Hab. in oceano pacifico ad ins. "Ellice", leg. David! ad "Archipelago Paumotu", leg. Seurat!

Planta brunnea, pro more frondibus duabus pluribusve e basi incrassata ortis; stipes

brevis (ad 2.5 cm. longus) crassus (ad 1.25 cm. latus) superne frondem cordato-semirotundatam 5.6 cm. longam, 8 cm. latam, ezonatam margine integram crassiusculam (haud membranaceam) sustinens. Frondis filamenta tenuia decrescentia interne circa 25 μ crassa externe ad apices circa 6 μ crassa, copiose et valde torulosa, pallida vel brunneola, ad apices saepe tortuosa, vel hamata, in pseudo-corticem haud intertexta sed facile separabilia, ad dichotomias divaricata. [Figs. 103, 104].

p. 38. *Avrainvillea lacerata* J. G. Agardh

forma *typica* nov. forma.

Hab. in oceano pacifico et in indico.

Frondes ramis dichotomis ad 2 cm. longis suffultae, cuneatae plerumque obovatae laceratae, interdum zonatae. [Figs. 105—107].

var. *robustior* n. var. (forsitan species propr. *Avrainvillea robustior*).

Hab. in oceano indico ad "Singapore", leg. Ridley!

Rhizoma breve crassum in ramos paucos, e quibus frondes sat confertae, stipitibus brevibus (3—10 mm. longis) suffultae, oriuntur, divisum. Frondes cuneato-oblongae vel cordato-rotundatae, interdum altera alteram intersecantes, sat tenues, zonatae, integrae fimbriataeve, filamentis ad constrictiones supra-dichotomiales longicollibus. Planta quam f. typica omnino robustior et uberior. [Fig. 108].

p. 42. *Avrainvillea amadelpha* A. & E. S. Gepp

forma *Montagneana* nov. forma.

Hab. in oceano indico et in mari rubro.

Planta minor (6 cm. alta), frondibus numerosis, dense congregatis, parvis, valde erosis, obsolete zonatis. [Fig. 112].

forma *submersa* nov. forma

Hab. in oceano indico profunde immersa, ins. Amirante, Saya de Malha, et Cargados Carajos, leg. J. S. Gardiner!

Planta procerior (ad 18 cm.), frondibus paucis, magnis, integris, zonatis. [Fig. 115].

pp. 10, 45. *Rhipiliopsis* n. gen.

Planta haud calcareo-incrustata viridis parva stipitata, stipite tenui, brevi; fronde excentrice subinfundibuliformi vel flabellata tenui raro zonata, e filamentis dichotomis cylindricis laxe intertextis, hic illic inter sese per tuberculorum abbreviatorum oppositorum paria pseudoconjugatis, constituta; filamentorum constrictionibus supra quamque dichotomiam symmetrice sitis.

p. 55. *Rhipilia tomentosa* Kutzing

forma *typica* nov. forma.

Hab. in oceano atlantico in Antillis, Herb. Kutzing!

Planta robustior, fronde cuneato-flabellata, crassiuscula, subezonata. [Figs. 126—128].

forma *zonata* nov. forma.

Hab. in oceano atlantico in mari Indiae occidentalis ad ins. "St. Jan", leg. F. Börgesen!

Planta tenuior, stipite graciliori, fronde rotundato-flabellata vel reniformi, tenui, translucide zonata. [Fig. 129].

p. 50. *Rhipilia tenaculosa* n. sp.

Hab. in oceano atlantico prope oras Brasiliae, "Barra Grande", profunde immersa, leg. "Challenger Expedition"!

Planta tenuis, dilute vel saturate viridis, solitaria vel frondes paucae e rhizomate eodem ortae; stipes 1—1.5 cm. longus, 0.15—0.2 cm. crassus, superne compressus et in frondem subito expansus. Frons usque ad 6.5 cm. longa et lata, rotundato-flabellata vel subinfundibuliformiter et excentrice peltata, tenuis, fissilis, pro more distincte zonata, margine integra fimbriata lobata laceratave: filamentis plerumque circa 40 μ crassis, in statu sicco collapsis et complanatis, ramulis lateralibus plerumque brevissimis (circa 50 μ rarius ad 150 μ longis), crassis, ad filamenta primaria numerosissimis, plerumque vere lateralibus. Stipitis filamenta iis frondis similia sed rhizoides paucas emittentibus. [Figs. 130—133].

p. 57. *Rhipilia orientalis* n. sp.

Hab. in oceano indico, ad "Borneo Bank" et ad "Fau" ins., leg. "Siboga Expedition".

Plantae brunneo-virides, parvae, gregariae, stipitatae; stipite ad 1 cm. longo, 0.1—0.2 cm. crasso, superne in frondem parvam, 1—3 cm. longam et latam, diversiformem, tum infundibuliformiter et excentrice peltatam, tum cuneatim vel rotundatim flabellatam, reticulatam, tenuissimam, translucidam, paene telae quae "muslin" dicitur brunneo-tinctae similem, haud vel vix zonatam, margine fimbriatam vel laceratam, expanso. Frondis (in alcohol conservatae) filamenta 30—50 μ crassa, laxissime intertexta, ramulos pseudo-laterales longos (70—350 μ sed plerumque circa 170 μ longos) sat multos, sed haud numerosissimos, gerentia, ramulis vere lateralibus raris nullisve. [Figs. 134—136].

pp. 11, 62. *Rhipidodesmis* nov. gen.

Planta haud calcareo-incrustata viridis parva, e filamentis gregariis laxe caespitosis, inferne decumbentibus et laxe intertextis, supra ascendentibus apice complanato-fastigiatis, constituta; filamentorum constrictionibus supra quamque dichotomiam symmetrice sitis; dichotomiis inferioribus remotis, superioribus approximatis.

pp. 11, 64. *Boodleopsis* nov. gen.

Planta haud calcareo-incrustata, viridis, pulvillos minutos, e filamento primario decumbenti inconspicuo monosiphoneo ramoso, inferne in rhizoides dichotomos tenuissimos diviso, supra decrescente et ramos dichotome vel trichotome et divaricate iterum iterumque intervallis brevibus ramosissime divisos et laxe intertextos emittente, constitutos efformans; filamentorum constrictionibus supra quamque dichotomiam symmetrice sitis.

p. 64. *Boodleopsis siphonacea* n. sp.

Hab. in oceano indico ad "Dongala, Palos-bay" et ad "Muaras-reef", legit "Siboga Expedition"!

Planta depressa dense pulvinata, 1—5 cm. lata. Filamentum primarium tegmine ramulorum intertextorum paene celatum, inferne circa 70 μ crassum (sed quoad crassitudinem varians), amyli micis granulosum, parietibus 10—12 μ crassis, hic illic minute striatis; ramulis inferioribus descendentibus et in rhizoides graciles laxe dichotomias circa 10 μ crassis divisisis; ramulis superioribus singulis vel binis e filamento primario decrescente intervallis irregularibus ortis; his ramulis tum ad quemque nodum, tum ad quemque secundum vel tertium nodum, iterum iterumque divisis, cylindricis, crassitudine sat aequalibus (22—25 μ); ramulorum segmentis (internodiis) plerumque 100—150 μ longis, viridibus vel pallidis, dense vel laxe granulosis, leptodermis, rectis, ad nodos constrictis, interdum tumores brevissimos interdum ramulum vere lateralem gerentibus. [Figs. 147—152].

Udoteae.

p. 67. *Tydemania Gardineri* n. sp.

Syn. *Tydemania expeditionis* A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908. p. 174, pro parte; et in op. cit. (Zool.) vol. XII. 1909. p. 384, pro parte (figuris etiam exclusis).

Hab. in oceano indico ad "Chagos Archipelago, Salomon" et ad "Amirante", leg. J. S. Gardiner!

Plantae depressae, laxe caespitosae, calcareo-incrustatae. Filamentum primarium prostratum, monosiphoneum, cylindricum, 350—400 μ crassum, hic illic ramulos, alios cylindricos et rhizoidibus lentis et matrici tenaciter haerentibus instructos, alios moniliformes et primum trichotome deinde quinquies sexiesve dichotome divaricate intervallis brevibus decussatim divisos, et ad ramulorum postremorum 4—6 stricturis ornatorum 250 μ crassorum apices flabella singula gerentes, emittens. Flabella monostromatica e filamentis cylindricis a latere connatis, dichotome ramosis, superne 50 μ (raro 40 μ) crassis, internodiis basalibus brevissimis 200 μ crassis, constituta. Glomeruli desunt. [Fig. 155].

p. 89. *Penicillus Sibogae* n. sp.

Hab. in oceano indico ad ins. Timor "Bay of Noimini", leg. "Siboga Expedition".

Planta (immatura?) circa 1 cm. longa, e filamento solitario ramoso calcareo-incrustato constituta, *Esperae mediterraneae* vel plantulis immaturis *Penicilli nodulosi* similis sed minor

gracilioreque. Filamentum simplex, inferne radiculiforme et haud incrustatum, supra calcareo-incrustatum et dichotome (raro trichotome) et decussatim ramosum, infra quamque dichotomiam parum inflatum, ramis ad basim constrictis, proxime supra basin saepe (interdum alibi) subtorulosis, 140—95 μ crassis, parietis integumento calcareo minute poroso. [Figs. 181, 182].

p. 111. *Udotea papillosa* n. sp.

Hab. in oceano indico ad ins. Timor, "Bay of Noimini, reef"; ad ins. Kangeang, et ad ins. Bawean, "Sankapura roads, reef", leg. "Siboga Expedition".

Plantae plerumque parvae, usque ad 2 cm. altae. Stipes (vel filamentum primarium) plantae juvenilis simplex, erectus, monosiphoneus, supra papillatus, haud calcareo-incrustatus, 70—100 μ crassus; stipes primarius plantae senioris (1 cm. altae et ultra) rhizoidibus undique descendentibus satis obtectus. Frons valde calcareo-incrustata, pro more 1 cm. longa 0.5—1.0 cm. lata, cuneato-flabelliformis, monostromatica, striata, haud zonata, saepe valde lacerata, hic illic prolificans. Frondis filamenta 30—45 μ crassa (papillis exclusis), stricta monostromatice inter sese a latere juxtaposita et conglutinata, papillis numerosis approximatis obtusis vel mamillatim apiculatis conicis, ordine simplice vel duplice praeter cujusque filamenti frontem et dorsum dispositis, et plerumque invicem per paria oppositis, instructa; filamentorum inferiorum papillae interdum in verticillis crebris dispositae, interdum furcatae vel geminatae. Constrictiones supra-dichotomiales asymmetricae. [Figs. 17, 20, 24, 37, 38].

p. 112. *Udotea papillosa*

subsp. *subpapillata* n. subsp. (forsan spec. prop.).

Hab. in oceano indico profunde submersa prope oram australem insulae Timor, leg. "Siboga Expedition".

Planta major 5 cm. alta. Frons 4.5 cm. longa, 2 cm. lata, zonata; differt a typo papillis valde humilioribus et obtusioribus, saepe inconspicuis paulo laxius dispositis; frondis filamenta superne circa 30 μ, inferne circa 55 μ crassa, prope basin fibulis brevibus 30—70 μ longis irregulariter instructa. [Figs. 39—42].

p. 119. *Udotea orientalis* n. sp.

Syn. *Udotea suborbiculata* Sond. in Muell. Fragm. Austral. XI. Suppl. 1880. p. 38.
Udotea Palmetta J. G. Agardh Till Alg. Syst. V. 1887. p. 71.
Udotea infundibulum Hauck in Hedwigia XXVII. 1888. p. 92.
Udotea Palmetta De Toni Syll. Alg. I. 1889. p. 506.
Udotea infundibulum Hieronymus in Engler Pflanzenw. Ostafr. Teil C. 1895. p. 24.
Udotea conglutinata Okamura Icon. Japan. Algae I. 1908. p. 231, tt. XLIV, XLV.
Udotea conglutinata A. & E. S. Gepp in Trans. Linn. Soc. (Bot.) VII. 1908. p. 175; and (Zool.) XII. 1909. p. 385.

Hab. in oceano indico, in Archipelago malayano ad ins. "Tanah-Djampeah" et alibi! ad Africae oras orientales! et in oceano pacifico!

Plantae usque ad 7 cm., plerumque circa 5 cm., longae, satis calcareo-incrustatae, Rhizoides in glebam vel in fibras granosas coarctatae. Stipes simplex, usque ad 2 cm. longus,

1—2 mm. crassus, cortice spongioso seu velutinoideo obtectus, superne complanatus et in flabellum sensim expansus. Frons e basi vulgo cordata, raro cuneata, raro auriculata, subrotundata vel flabelliformis, circa 3.5 cm. longa, 5 cm. lata, viridi-canescens, zonata, superficie supra longitudinaliter filamentoso-striata, prope basim velutinoidea vel spongiosa, margine subintegra erosa vel raro lobata. Frondis filamenta 25—35 μ (raro 45 μ) crassa, paulum calcareo-incrustata, e stipite ad marginem radiatim disposita, iterum iterumque dichotome ramosa, supra quamque dichotomiam asymmetrice constricta, flexuosa, inter paginas pluriseriata, plerumque inter sese crebre juxta-posita et conglutinata; prope basin filamenta ramellis lateralibus fibulisve paucis brevibus simplicibus instructa. Stipitis filamenta ramellis lateralibus dichotome divisis et bullas apicales parvas breves obtusas, interdum ovoideas, gerentibus instructa. [Figs. 1, 4. 47, 48].

p. 120. *Udotea explanata* n. sp.

Syn. ? *Flabellaria Palmetta* Kützing Tab. Phyc. vol. VIII. 1858. p. 12, tab. 27, fig. 1.
? *Udotea Palmetta* Sonder ex Kützing loc. cit.
? *Udotea Kützingii* De Toni Sylloge Algarum I. 1889. p. 511.

Hab. in oceano indico ad ins. Celebes, leg. "Siboga Expedition"! forsan in sinu Arabico, leg. Sonder.

Planta circa 7.5 cm. alta. Stipes 1.5 cm. longa, inferne cylindrica 2 mm. crassa, superne compressa (5—6 mm. lata) et in frondem (quod ad structuram attinet) sensim transiens, cortice spongioso-velutinoideo et in frondis basin per spatium parvum (circa 2 mm.) extenso. Frons e basi truncata semiorbicularis (5 cm. alta, 10 cm. lata) valde lacerata, margine irregulariter lobata, obscure zonata, lurido-canescens, fissilis, parum conglutinata, superficie fibrosa velut villo appresso obtecta. Frondis filamenta plerumque 50—65 μ crassa, e stipite ad marginem velut radii abeuntia, pluriseriata, inter sese parallela, fere stricta, calcareo-incrustata, porosa, supra dichotomias constrictionibus symmetricis (numquam distincte asymmetricis) notata. Stipitis filamenta ramellis lateralibus dichotome divisis et cymos bullarum apicalium parvarum brevium obtusarum vel truncatarum gerentibus instructa. [Figs. 49, 50, 51].

p. 125. *Udotea spinulosa* Howe
forma *palmettoidea* nov. forma.

Syn. *Udotea conglutinata* Dickie in Journ. Linn. Soc. (Bot.) vol. XIV. 1875. p. 312, pro parte.

Hab. in oceano atlantico ad ins. "St. Thomas" leg. "Challenger Expedition"!

Frondis filamenta ramellis unilateraliter velut in planta typica dispositis, sed minoribus (10 μ longis), 1—3-fidis instructa; ramelli supra sessiles, inferne 2—3-fidi, interdum simplices, 40—70 μ (interdum usque ad 110 μ) longi, pedicellati, semper acuti; ultroque versus apices filamentorum per spatium 2—3 mm. hi ramelli laterales omnino desunt. [Fig. 56].

p. 126. *Udotea argentea* Zanardini
forma *typica* nov. forma.

Hab. in oceano indico, in mari rubro, et in oceano pacifico.

Planta 3—10 cm. alta. Frons subreniformi-flabellata vel rotundata, interdum valde

prolificans, superficie minutissime et obscure cellulosa vel spumosa (raro evidenter spumosa vel polyporoidea); filamenta 40—60 μ crassa ramellis lateralibus capitatis instructa; ramellorum capitula valde et varie 2—6-lobata, interdum tuberibus 2—9 subhemisphericis exornata, interdum complanata et subpalmatim lobata. [Figs. 21, 22*c*, 22*d*, 57—60].

p. 126. *Udotea argentea* Zanardini

var. *spumosa*. nov. var.

Hab. in oceano indico, ad ins. "Tanah-Djampeah" etc., leg. "Siboga Expedition"!

Planta usque ad 15 cm. alta, 23 cm. lata, prolificationibus late imbricatis instructa. Frondis superficies evidenter spumosa vel polyporoidea; filamenta 40—60 μ crassa, ramellis lateralibus elongato-pyriformibus, plerumque simplicibus, apice tum rotundatis (versus basim frondis) tum planis vel depressis (versus apicem frondis), instructa. [Figs. 15, 25*a*, 61, 62].

p. 127. *Udotea occidentalis* n. sp.

Hab. in oceano atlantico in Antillis ad ins. "St. Thomas", leg. "Challenger Expedition"! ad ins. "St. Jan", leg. F. Börgesen!

Planta usque ad 8 cm. alta, valde calcareo-incrustata. Rhizoides in glebam parvam fibrosam coarctatae. Stipes simplex teres brevis (usque ad 1 cm. longus) gracilis (1.5 cm. crassus). Frons inferne cineracea, superne viridis, e basi cuneata obovata, satis prolificans, parum striata, superficie minutissime et obscure cellulosa; filamenta 30—45 μ crassa, approximata, raro contigua, pluriseriata, ramellis lateralibus capitatis circa 70—120 μ longis (raro usque ad 180 μ prope frondis basim) instructa; ramellorum capitula simplicia vel lobate divisa, inflata et tuberibus 6—20 leniter eminentibus (quae specularibus in superficie calcareo-incrustata quadrant [confer p. 103]) exornata; constrictionibus supra-dichotomialibus asymmetricis. Stipitis filamenta ramellis lateralibus longipedicellatis, superne bis vel ter dichotomis, deinde breviter et irregulariter divisis et bullas apicales numerosas, perbreves obtuse rotundatas gerentibus, instructa. [Figs. 18, 22*a*, 22*b*, 63—65].

p. 130. *Udotea Wilsoni* Gepp et Howe n. sp.

Hab. in oceano atlantico ad ins. "Anguilla", leg. P. Wilson!

Planta circa 10 cm. alta, satis calcareo-incrustata, stipitata; stipite usque ad 4 cm. (plerumque 1—1.5 cm.) longo, simplice vel superne ramosa, ramis brevissimis liberis vel conglutinatis. Frons e prolificationum flabelliformium numerosarum congerie laminata constituta; prolificationes altera ex alterius superficie et plerumque e situ, qui propinquus et parallelus axi congeries centrali (quasi stipiti sursum prolongato) est, ortae. Frondis lamina quaeque vulgo e basi semi-cordatà semirotundata vel semiflabellata, integra vel lobata, striata, interdum zonata, cineraceo-viridis, margine juvenili flavescente, adultiore cinerascente; superficie minutissime spongiosa vel granulosa. Frondis filamenta 40—50 μ crassa, subparallela et ramis flexuosis intricatis commixta, pluriseriata, parce dichotoma, sine constrictionibus supra-dichotomialibus,

ramellis lateralibus brevibus simplicibus vel furcatis obtusissimis crebre instructa. Ramelli laterales plerumque ordinibus duplicibus duobus qui alter ad frondis frontem et alter ad dorsum diriguntur, dispositi, circa 25—40 μ longis, in frondis parte superiori; ramelli in frondis parte inferiori minus regulariter dispositi, plerumque distiche secundi et hic illic interrupti, quoad longitudinem valde inaequales, 25—120 μ longi. Stipitis filamenta ramellis lateralibus semel vel saepius dichotome divisis et apices obtusos gerentibus instructa. [Figs. 66—68].

p. 135. *Codium petaloideum* n. sp.

Hab. in oceano indico ad ins. Sabangkatan prope Borneo, leg. "Siboga Expedition"!

Planta pusilla, laete viridis, 10—12 mm. alta, 5—7 mm. lata, complanata, obovata, subsessilis. Strati exterioris utriculi subpyriformes, superne obtuse rotundati, sed saepe parum impressi, parvi, 180—240 μ longi, 115—180 μ lata, apice nullis membranae augmentis conspicue muniti. [Figs. 193, 194].

p. 136. *Codium divaricatum* n. sp.

Hab. in oceano indico ad "Elat", ins. Kei major et ad "Kwandang Bay", ins. Celebes, leg. "Siboga Expedition"!

Planta procumbens, repens, rhizoidibus hic illic adfixa, caespitem circa 8 cm. latum efformans, valde et divaricato-dichotome ramosa, ubique gracilis, in statu sicco 1.5—0.5 mm. crassa, ramis laxe intricatis. Strati exterioris utriculi obovato-clavati vel subpyriformes, parvi, 300—360 μ longi, 96—200 μ lati, ibique parietibus tenuibus. [Figs. 195—199].

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EXPLANATION OF PLATES

(N.B. Plates I—IV were prepared and printed off in 1903, and unfortunately fail to emphazise certain points which we now hold to be of essential importance for a true appreciation of the respective species. So far as possible we have endeavoured to maintain a uniformity in the magnifications of the figures throughout each genus and in allied genera).

PLATE I.

Udotea (figs. 1—28, 36—68).

Fig. 1. *Udotea orientalis* n. sp. Habit of plant, nat. size. (Landu Bay, Rotti, reef, Siboga Expedition).

Fig. 2. *U. cyathiformis* Decaisne. Habit of plant, nat. size. (Iles des Saintes, Guadeloupe, *D'Avrainville* in Herb. Mus. Paris. DECAISNE's type).

Fig. 3. *U. glaucescens* Harvey. Habit of plant, nat. size. (Friendly Islands, *Harvey*. n° 82, in Herb. Mus. Brit.). The frond consists of two lamellae, the smaller superposed on the larger; they both arise from the same stipes, which is inconspicuously divided at its upper end.

Fig. 4. *U. orientalis*. Surface view of frond filaments of plant shown in fig. 1, before decalcification. × 20.

Fig. 5. *U. glaucescens*. Surface view of frond filaments of plant shown in fig. 3, before decalcification. × 20.

Fig. 6. *U. cyathiformis*. Filaments of frond of fig. 3 after decalcification, showing sessile even constrictions (erroneously made to appear septate) above the dichotomies. × 83.

Fig. 7. *U. glaucescens*. Filaments of frond of fig. 3 after decalcification, showing two dichotomies and a trichotomy; the constrictions are all more or less badly represented in this figure, especially those of the upper dichotomy, which ought to be markedly uneven (as in fig. 47) and not sessile. × 83.

Fig. 8. *U. glaucescens*. *a*. Lateral appendages of filaments of stipes with the apices inadequately rendered, × 83; *b*. single apex of same, × 472.

Fig. 9. *U. cyathiformis*. Rhizoids springing from a root-axis, × 83; *a*. the same, × 2.

Fig. 10. *U. palmetta* Decaisne. Habit of plant, nat. size. (DECAISNE'S type, Coll. *du Petit Thouars* in Herb. Mus. Paris).

Fig. 11. *U. palmetta*. Filaments of frond, showing lateral appendages both simple and forked and trifid, usually sessile (rarely shortly pedicellate), arranged along one side of the filament. As explained in the text, the lateral appendages are borne only on the exposed portions of the filaments, which constitute the frond, viz., along that side which formed part of the external surface of the frond. *a*. and *b*. side view, × 178. In *a* there is between the appendages a bare space, which was filled by another filament crossing it externally. *c*. surface view, seen from above, × 178. *d*. × 472.

Fig. 12. *U. spinulosa* Howe. Filaments of frond showing lateral appendages, forked and spinose, occurring, as explained under fig. 11, only on the exposed side of the filament, × 83. This filament, being situated in a thin part of the frond, emitted appendages here and there where exposed on each surface of the frond. *b*. apex of filament × 83. *c*. single lateral appendage with three acute spines, × 472. (Specimen without locality, in *Herb. Chauvin*).

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PLATE II.

Fig. 13. *Udotea indica* n. sp. Filaments of frond from basal margin, showing truncate papillae, which, like the appendages of *U. palmetta* and of *U. spinulosa*, occur only on the exposed side of the filaments. The supra-dichotomial constrictions are very uneven and, in nature, are much more strongly constricted than as represented in the figure; *a* and *b* × 83; *c* × 178.

Fig. 14. *U. indica*. Filaments of stipes, shewing lateral appendages, × 83.

Fig. 15. *U. argentea* Zan. var. *spumosa* nov. var. Part of large plant, nat. size. (Saleyer, reef. Siboga Expedition).

Fig. 16. *U. verticillosa* A. & E. S. Gepp. Habit of plant, nat. size. (St. Thomas, West Indies, "*Challenger*" Expedition, 5—15 fathoms).

Fig. 17. *U. papillosa* n. sp. Small plants, or, strictly speaking, proliferations broken off from a larger plant, nat. size, (Siboga Expedition).

Fig. 18. *U. occidentalis* n. sp. Surface view of frond, before decalcification, showing the sinuous lines of demarcation between the contiguous inflated capitula of the lateral appendages, which are borne on the filaments of the frond and form a cortical covering of the frond. In each of the sinuous areas depicted are seen three or more of the "windows" described in the text. × 472. (West Indies, St. Thomas, "*Challenger*" Expedition, in Herb. Mus. Brit.).

Fig. 19. *U. verticillosa*. Surface view of frond, before decalcification, shewing encrusted spinose filaments, × 20.

Fig. 20. *U. papillosa* n. sp. Surface view of frond, before decalcification, seen by surface illumination. *a*. near upper margin; *b*. near base, × 70.

Fig. 21. *U. argentea* Zan. Portion of frond after decalcification, showing main filaments bearing lateral appendages (for comparison with the lost type-specimen from Suez, figured by ZANARDINI in his Plant. mar. rubr. coll. tab. XII. fig. 1*b*), × 83.

Fig. 22*a* and *b*. *U. occidentalis*. *a*. Filaments of frond, shewing lateral appendages of nearly equal length, with pluri-lobulate inflated capitula. × 83. *b*. Two of these lateral appendages shewing stalk expanding above obconically, and dividing into two or more embossed inflated lobules, each bearing some six of the "windows" described in the text. × 472.

Fig. 22*c*. *U. argentea* f. *typica*; part verging towards var. *spumosa*. *c*. Filament of frond, showing lateral appendages with stalked, longly obconic capitula, rounded, flattened, or depressed at apex, simple or occasionally lobed. Other filaments of the same plant bear the lobate and embossed lateral appendages of f. *typica*. (Karkaralong, Siboga Expedition) × 83. [Fig. 22*d* is on plate III].

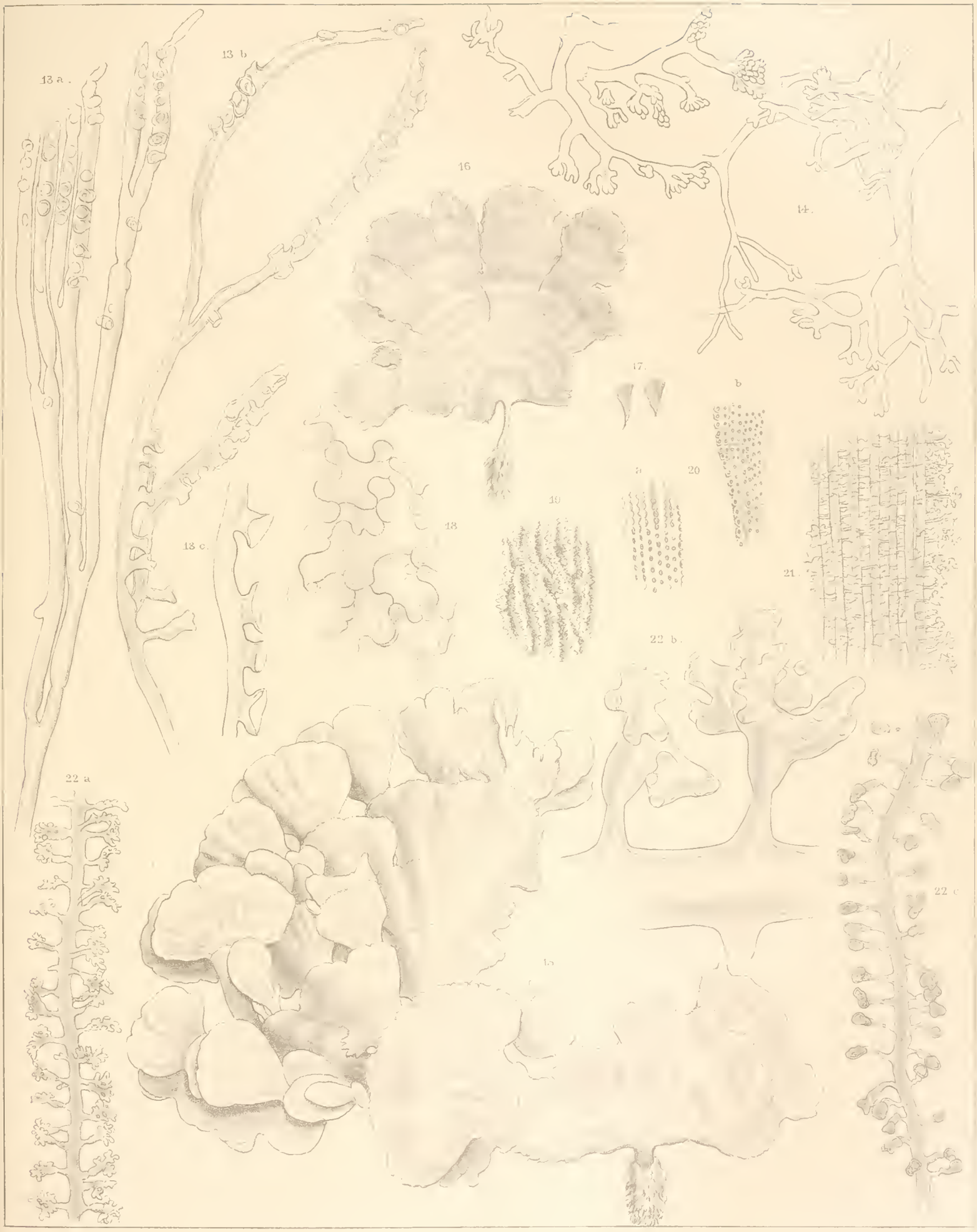

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PLATE III.

Fig. 22*d*. *Udotea argentea* f. *typica*. Two separate lateral appendages of fig. 22*c* × 472. These are exceptional in their simple form and in their flattened apex; the normal form is lobate and usually embossed (see fig. 59). The thickened rim in the upper figure is an erroneous representation.

Fig. 23. *U. verticillosa*. *a*. Filament of frond, shewing numerous close verticils of spinose lateral appendages. *b*. single lateral appendage, twice forked and having acute apices × 472.

Fig. 24. *U. papillosa*. Filaments of frond. *a*. lateral view, shewing papillae in profile arranged pair-wise front and back × 178. *b*. surface view of same papillae foreshortened, being seen from above × 178. *c*. and *d*. Papillae enlarged, mamillate or obtuse, × 472.

Fig. 25*a*. *U. argentea* var. *spumosa*. Filament of stipes, with lateral appendages × 83.

Fig. 25*b*. and *c*. *U. verticillosa*. *b*. Filament of stipes with lateral appendages × 83; *c*. lateral appendage, with characteristic thick wall, × 472.

Fig. 26. *U. flabellum* Howe. Habit of plant. (Guanico, Porto Rico, Herb. *Hauck*) nat. size.

Fig. 27. Ditto. *a*. Filament of frond with digitate lateral appendages of unequal length (Grenada, *Murray*) × 83; *b*. ultimate division of lateral appendage with bifid, truncate apices × 472.

Fig. 28. Ditto. *a*. Filament of stipes with lateral appendages × 83; *b*. ultimate divisions of a lateral appendage with obtuse thick-walled apices × 472.

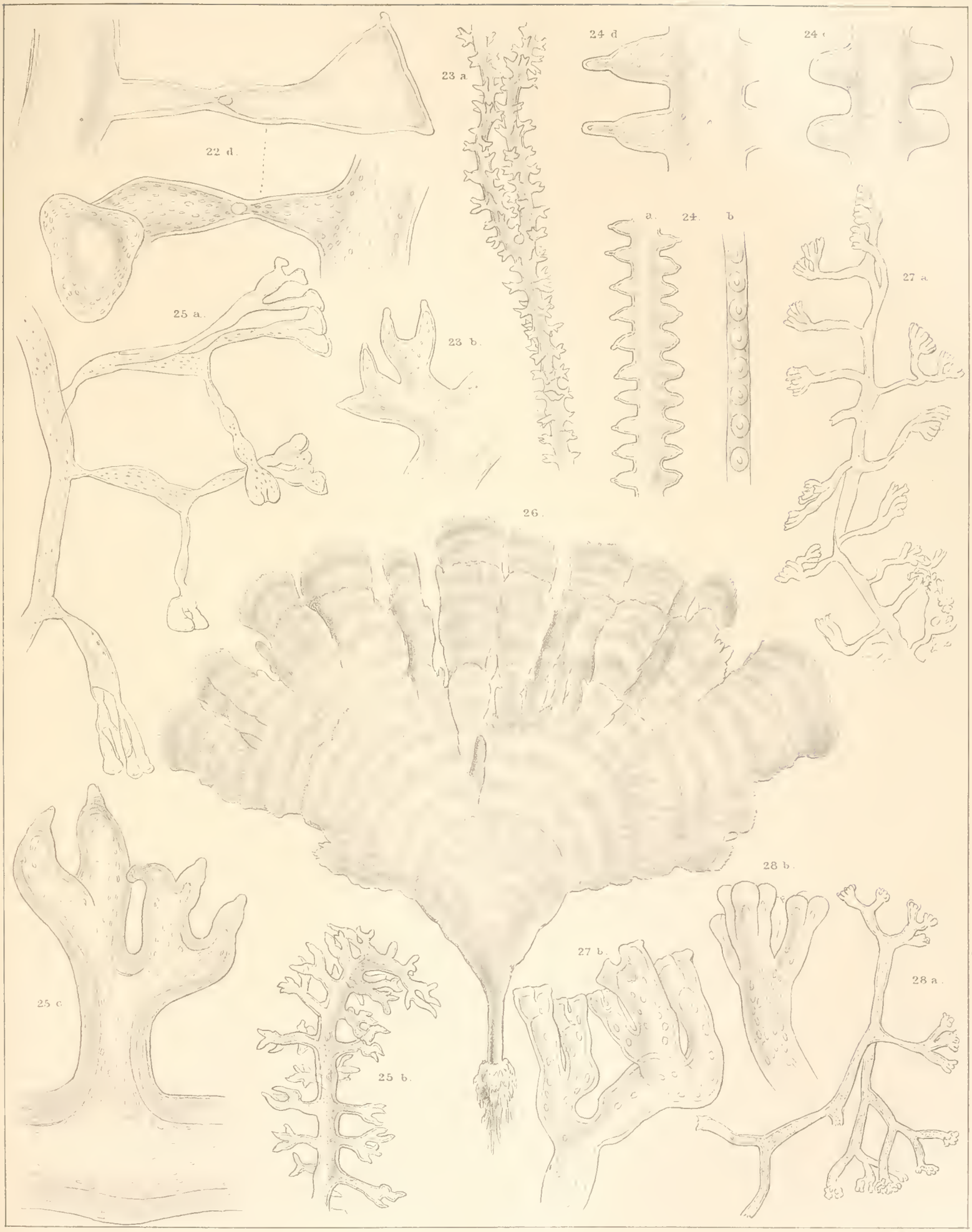

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PLATE IV.

Flabellaria (see also figs. 123—125 on plate XV).

Fig. 29. *Flabellaria petiolata* Trevisan. Habit of plant. Several plants arising from a common root-mass, attached to *Pescidonia* (Melos, Herb. *Chauvin*), nat. size. The fronds are really faintly and narrowly zonate, a feature which this figure fails to show.

Fig. 30. Ditto. *a*. Filaments of frond shewing lateral appendages of unequal length × 83; *b*. part of a single lateral appendage consisting of a stalk and part of its botryoidally lobulate terminal expansion × 472.

Fig. 31. Ditto. Filament of stipes with lateral appendages: *a*. × 178; *b*. ultimate divisions of lateral appendage with blunt apices (thick-walled in reality) × 472.

Cladocephalus (see also figs. 137—140 on plate XVI and XVII).

Fig. 32. *Cladocephalus luteofuscus* Börgesen. Habit of plant (Guadeloupe, *Mazé* n°. 1904, in Herb. Mus. Brit.) nat. size.

Fig. 33. Ditto. *a*. and *b*. Branches of main filaments of front of the same, densely ramified at apex × 83; *c*. terminal ramification × 178; *d*. ultimate ramelli × 472. These terminal ramifications combine to form the felt-work, which covers the main filaments.

Fig. 34. Ditto. *a*. Filaments of frond (Herb. *Chauvin*) shewing terminal ramification of branches × 83; *b*. ultimate ramelli × 472.

Fig. 35. Ditto. *a*. Filaments of stipes (Guadeloupe, *Mazé* n°. 1904) shewing ramification of branches × 83; *b*. ultimate ramelli of same (thickwalled in reality) × 472.

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PLATE V.

Udotea (see also figs. 1—28 on plate I—III).

Fig. 36. *Udotea orientalis* A. & E. S. Gepp. *a.* Habit of plant, nat. size. (Maumeri, Sep. 1888, n°. 1037. Madame *Weber van Bosse*). *b.* Plant (Sankapura, Bawean, Siboga Expedition), consisting of monosiphonous stipes and monostromatic frond, × 22. *c.* Base of frond (Sankapura) with monosiphonous stipes and hyaline rootlets × 30.

Fig. 37. *Udotea papillosa* n. sp. Habit of plant (Noimini Bay, Siboga Expedition). This consists of a flabellate frond arising by ramification from a short fascicle of a few erect parallel papillate branches, which themselves arise by dichotomy from the apex (*a*) of the primary axis. The primary axis is concealed by the numerous rhizoids which spring from it. × 8.

Fig. 38. Ditto. Portion of dichotomous filament from base of a proliferation, showing whorls of obtuse or truncate papillae. (Sankapura, Bawean, Siboga Expedition). × 178.

Fig. 39. *Udotea papillosa* subspec. *subpapillata*. Habit of plant (nat. size), showing absence of stipes, East coast Timor, Siboga Expedition). [*Udotea subpapillata* will probably prove to be a proper species.]

Fig. 40. Ditto. Base of plant, showing primary filament surrounded by a loose system of branching rhizoids which issue from it at different levels. The primary filament divides above into a fascicle of a few erect branches, which constitute a very short compound stipes; this bears a flabelliform frond produced by the further ramification of the aforesaid branches in one plane. Only the extreme base of the frond is shown in the drawing. In the portion here called "stalk" the rhizoids are seen to be reduced and soon replaced above by long papillae or fibulae. These fibulae occur also on the lowermost part of the frond, but above are replaced by inconspicuous papillae. × 20.

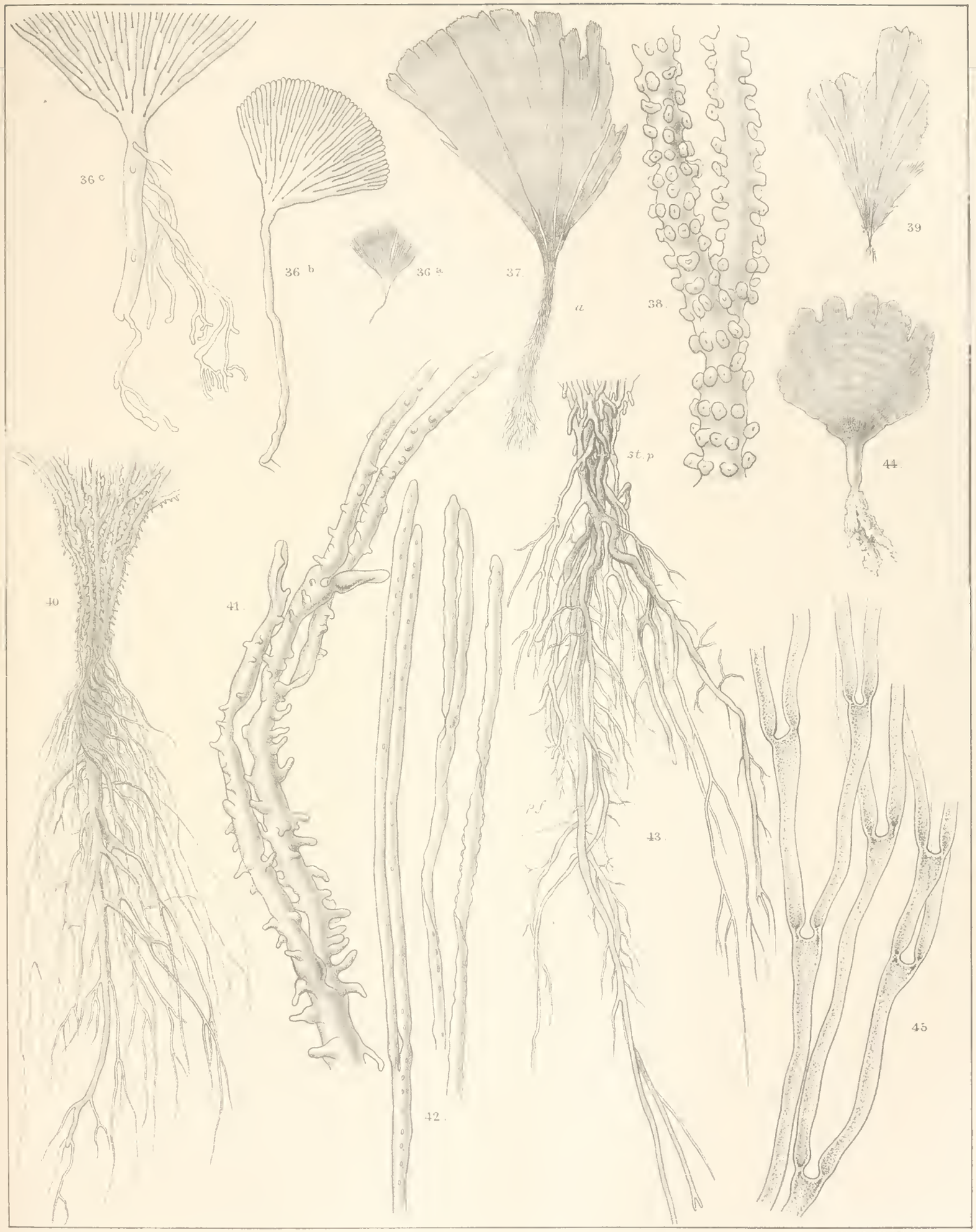
Fig. 41. Ditto. Portion of short branched filament from base of frond (viz. from upper part of preceding figure, fig. 40). × 83. It bears long papillae, which correspond to the fibulae of *U. orientalis* and *U. conglutinata*.

Fig. 42. Ditto. Apical portion of a few frond-filaments from upper part of frond × 83. The papillae, never conspicuous, are sometimes absent.

Fig. 43. *Udotea glaucescens* Harvey. Base of a plant × 20 (Lirung, Siboga Expedition), showing the developing condition of the stipes; the starting-point (st. p.) probably was at about the place indicated, where the uppermost rhizoids appear to originate; these rhizoids spring from a primary descending filament or rhizoid which may easily be traced (p. f.) to the lowest point of the figure. Above the starting-point (st. p.) a fascicle of filaments branching off from the primary filament, ascends (young compound stipes); and these filaments, dividing at intervals, soon spread out so as to form the flabellate frond. The basal filaments below the frond bear fibulae (short lateral branchlets of the same diameter as their own), which later, increasing greatly in number and dividing dichotomously, become approximated and combined into the the pseudo-cortex of the mature stipes. A few of these original fibulae are shown at the top of the figure. They are also found upon the base of the frond and form a tomentum there. The mature stipes, extending downwards, would gradually encompass and envelope the upper rhizoids shown in the figure.

Fig. 44. *Udotea conglutinata* Lamouroux. Habit of plant, nat. size. (Bahamas, *Howe* n°. 3240).

Fig. 45. Ditto. Filaments of frond of same plant, shewing frequent dichotomies and even supradichotomial constrictions, × 83.



P. Highley del.

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PLATE VI.

Fig. 46. *Udotea conglutinata*. Filament of stipes of same plant, showing lateral appendages dichotomously divided and terminated by dactyline apices, × 83.

Fig. 47. *Udotea orientalis* n. sp. Filaments of frond, showing uneven supra-dichotomial constrictions. (Landu Bay, Rotti, reef. Siboga Expedition). × 83.

Fig. 48 *a* and *b*. Ditto. Filaments of stipes from same plant, showing lateral appendages dichotomously divided and terminated by short obtuse apices, × 83.

Fig. 49. *Udotea explanata* n. sp. Habit of plant, nat. size. (Celebes. Siboga Expedition).

Fig. 50. Ditto. Filaments of frond, showing even constrictions, × 83.

Fig. 51. Ditto. Filaments of stipes showing lateral appendages; *a* × 83; *b* × 420.

Fig. 52. *Udotea indica* n. sp. *a*. and *b*. Habit of plant, nat. size. (Kurrachee, *Murray* in Herb. Mus. Brit.).

Fig. 53. Ditto. Portion of frond of same in surface view, showing distribution of papillae; these are formed on the outer surface only of the superficial filaments of the frond. Three filaments are raised and turned back to show the absence of papillae elsewhere, and at the same time reveal the oblique crossing of the filaments which constitute the frond. On the right of the figure is a loosened filament bare of papillae here and there, where it has been overlain by other filaments. (Kurrachee, *Murray*). × 83.

Fig. 54. *Udotea palmetta* Decaisne. Filaments of stipes showing lateral appendages; *a* × 83; *b* × 125.

Fig. 55. *Udotea spinulosa* Howe. Habit of plant, nat. size. (Bahamas, *Howe* n°. 3272 pro parte). Copy of photograph reproduced in Bull. Torrey Bot. Club vol. XXXVI. 1909. pl. 4, fig. 2.

Fig. 56. *Udotea spinulosa* f. *palmettoidea* n. f. Filaments of frond, showing even supra-dichotomial constrictions and secund lateral appendages × 83. (St. Thomas, "*Challenger*" Expedition, in Herb. Kew.). *a*. apices of a filament from upper part of frond; above and below the dichotomy are a few incipient lateral appendages. *b*. filament from base of frond with a few stalked lateral appendages; being an interior filament it is mostly destitute of appendages. *c*, *d*, *e*. portions of one and the same external filament from base of frond.

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PLATE VII.

Fig. 57. *Udotea argentea* forma *typica*. Habit of plant, nat. size. (Cargados Carajos, *J. S. Gardiner*. 47 fathoms).

Fig. 58*a*, *b*. Ditto. Filament of frond, shewing uneven supradichotomial constrictions and capitate lateral appendages of equal length. *a*. capitula botryoid (Cargados Carajos, *J. S. Gardiner*) × 83; *b*. capitula flattened and lobed (Lirung, Siboga Expedition) × 83. *c*. Filament shewing apex and more crowded lateral appendages. (Cargados Carajos, *J. S. Gardiner*) × 83.

Fig. 59. Ditto. Lateral appendages of fig. 58*a* (Cargados), shewing the pedicel with submedian constriction and inflated lobulate head, embossed with a few low prominences. × 472.

Fig. 60. Ditto. Lateral appendage of fig. 58*b* (Lirung), showing the pedicel with submedian constriction and the head complanately flattened, expanded and lobulate × 472.

Fig. 61. *Udotea argentea* var. *spumosa* var. nov. Filament from lower part of frond, showing uneven dichotomial constrictions and simple, inflated, capitate, lateral appendages of equal length. 83. (Saleyer. reef, Siboga Expedition.)

Fig. 62. Ditto. Lateral appendage of the same, showing the rounded apex × 472. In the upper part of the frond the apices of the appendages are flattened or depressed.

Fig. 63. *Udotea occidentalis* n. sp. Habit of type-plant, nat. size. (West Indies, St. Thomas, "*Challenger*" Expedition, in Herb. Mus. Brit.). This, the type specimen, is incomplete, being destitute of a stipes.

Fig. 64. Ditto. Habit of plant, nat. size. (West Indies, St. Jan, *Borgesen*, in herb. suo) complete plant with stipes.

Fig. 65. Ditto. Filaments of stipes showing lateral appendages, *a* × 125; *b* portion × 375. (West Indies: St. Jan, *Borgesen* n°. 1906 pro parte).

Fig. 66. *Udotea Wilsoni* n. sp. Habit of plant, nat. size. (Bahamas, *Howe*, n°. 7968).

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PLATE VIII.

Fig. 67. *Udotea Wilsoni*. Frond-filaments of same, showing very obtuse lateral appendages · 83. *a*. Fragment of same · 230. *b*. Apices of same · 83.

Fig. 68. Ditto. Filaments of stipes of same · 83. *a*. Portion of same · 375.

Chlorodesmis.

Fig. 69. *Chlorodesmis comosa* Bail. and Harvey. Plant showing creeping nodulose base, from which spring the ascending filaments. These are torulose for a short distance above their origin from the creeping base, and then become cylindrical and branch dichotomously. The lowest supradichotomial constrictions are even (*a*), the upper ones are very uneven (*b*). · 8. (Saleh Bay, Siboga Expedition).

Fig. 70. Ditto. Creeping basal filament from fig. 69, enlarged, showing toruloid constrictions. From it arise three torulose ascending filaments (as in fig. 69). The other branchlets are young stolons and rhizoids. · 40. (Saleh Bay, Siboga Expedition).

Fig. 71. Ditto. Dichotomy with even constrictions, situated at *a* in fig. 69. · 40. (Saleh Bay).

Fig. 72. Ditto. Dichotomy with very uneven constrictions, situated at *b* in fig. 69. · 40. (Saleh Bay).

Fig. 73. Ditto. *a*. Portions of plant showing (on right) basal stolons and (on left) upper filaments with uneven constrictions (Friendly Islands, *Harvey* n°. 90) · 8; *b*. dichotomy with uneven constrictions, · 40; *c*. rhizoid, torulose base and lowest dichotomy of an ascending filament, · 40.

Fig. 74. *Chlorodesmis Hildebrandtii* n. sp. *a*. Creeping basal portion of filament, showing stolons and rhizoids, · 8 (Comoro, *Hildebrandt* n°. 59); *b*. upper filaments · 8; *c*. dichotomy with even constrictions, × 40 (Comoro).

Fig. 75 *a*, *c*. Ditto. *a*. Portion of plant (Saleyer, Siboga Expedition) showing stolons and ascending filaments, · 8; *c*. dichotomy from upper portion of same plant, showing even constrictions. · 40. [Fig. 75 *b* is on plate IX.]

Avrainvillea.

Fig. 76. *Avrainvillea Rawsoni* Howe. Habit of plant, nat. size. (Barbados, *Rawson*). This species has no flabelliform frond.

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PLATE IX.

Chlorodesmis.

Fig. 75*b*. *Chlorodesmis Hildebrandtii*. Portion of fig. 75*a* × 40, with two ascending filaments marked *f*. [Fig. 75*a*, *c* are on plate VIII].

Avrainvillea.

Fig. 77. *Avrainvillea Rawsoni* Howe. Filaments of thallus in fig. 76 · 100. In this species the filaments are thin-walled, mostly torulose and pallid.

Fig. 78. *Avrainvillea nigricans* Decaisne. Habit of type plant, nat. size. (Guadeloupe, *D'Avrainville*, in Herb. Mus. Paris). This species usually attains much larger dimensions.

Fig. 79. Ditto. Frond-filaments of same plant 100. They are distinctly moniliform.

Fig. 80. Ditto. Frond-filaments of another plant 100 (St. Thomas, West Indies. "*Challenger*" Expedition

Fig. 81 on plate X.
in Herb. Mus. Brit.). The ultimate ramuli are divaricate and taper to their apices.

Fig. 82. *Avrainvillea Mazei* Murray and Boodle. Frond-filaments of plant shown in fig. 81 in plate X. · 100. They are cylindrical, not beaded, not tapering, are strongly constricted above dichotomy and often are deep orange-brown in colour.

Fig. 83. Ditto. Frond-filaments of second type plant × 100 (Guadeloupe, *Mazé*, n°. 1234 in Herb. Mus. Brit.).

Fig. 84. *Avrainvillea erecta* nov. comb. Habit of plant, nat. size. (Philippines, *Cuming*, n°. 2234 in Herb. Mus. Brit., being part of CUMING's original gathering).

Fig. 85. Ditto. Frond-filaments of type plant (*Dichonema erectum* Berk.) 100 (Philippines, *Cuming* n°. 2234 in Herb. Kew). In *A. erecta* the filaments are cylindric, not tapering, are strongly constricted above dichotomy, and are yellow to intensely fulvous.

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PLATE X.

Fig. 81. *Avrainvillea Mazei* Murray and Boodle. Habit of type plant, nat. size. (Guadeloupe, *Mazé*, n°. 65, 1ere série in Herb. Mus. Brit.). [See also fig. 82 on plate IX.]

Fig. 86. *Avrainvillea erecta*. Outline of type plant of *Chloroplegma papuanum* Zan. nat. size. (New Guinea, Sorong, *Beccari*). [Compare fig. 84].

Fig. 87. Ditto. Frond-filaments of authentic specimen of *C. papuanum* Zan. · 100. (New Guinea, Sorong, in Herb. Mus. Brit. ex Herb. *Beccari*).

Fig. 88. Ditto. Frond-filaments of a spirit specimen · 100. (Saleh Bay, Siboga Expedition 8—16 fathoms). The diameter of these filaments is greater than in the type.

Fig. 89. Ditto. Sporangia, empty, terminal on exserted filaments of the frond · 100. (Madras, *Thurston*, in Herb. Mus. Brit.); *a*. stopper at base of sporangiophore · 200.

Fig. 90 *a* and *b*. *Avrainvillea obscura* J. Ag. Outline of type plants, nat. size. (from Dr. O. NORDSTEDT's sketch of C. A. AGARDH's types in Herb. Lund).

Fig. 91. Ditto. Frond-filaments of same · 100 (from Dr. NORDSTEDT's sketches).

Fig. 92 *a* and *b*. *Avrainvillea clavatiramea* n. sp. Habit of plant, nat. size. (Port Phillip, Corio Bay, *J. Bracebridge Wilson* in Herb. Mus. Brit.).

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PLATE XI.

Fig. 93. *Axrauvillea clavatiramea*. Frond-filaments of same × 100. They are often torulose, dense green or orange, clavate at apices.

Fig. 94. *Axrauvillea Ridleyi* n. sp. Habit of plant, nat. size, spirit specimen. (Christmas Island, Flying Fish Cove, *C. W. Andrews* in Herb. Mus. Brit.). No flabellate frond of this species has yet been seen by us.

Fig. 95. Ditto. Filaments of same × 100. They are torulose or sometimes cylindric, with pale brown contents, sometimes subclavate at apices.

Fig. 96. Ditto. Frond-filaments of type (dried plant) × 100. (Christmas Island, Flying Fish Cove, *H. N. Ridley*. n°. 224).

Fig. 97. *Axrauvillea canariensis* n. sp. Habit of plant, nat. size. (Gran Canaria, Las Palmas, Madelle *A. Vickers*, in Herb. Weber van Bosse).

Fig. 98. Ditto. Frond-filaments of same × 100. They are torulose here and there, not tapering, nor clavate, are green to fulvous brown, but often collapsed and colourless.

Fig. 99. *Axrauvillea Elliottii* n. sp. Habit of plant, nat. size. (Grenada, *W. R. Elliott*, spirit specimens in Herb. Mus. Brit.). [See also fig. 99*a* on plate XII.]

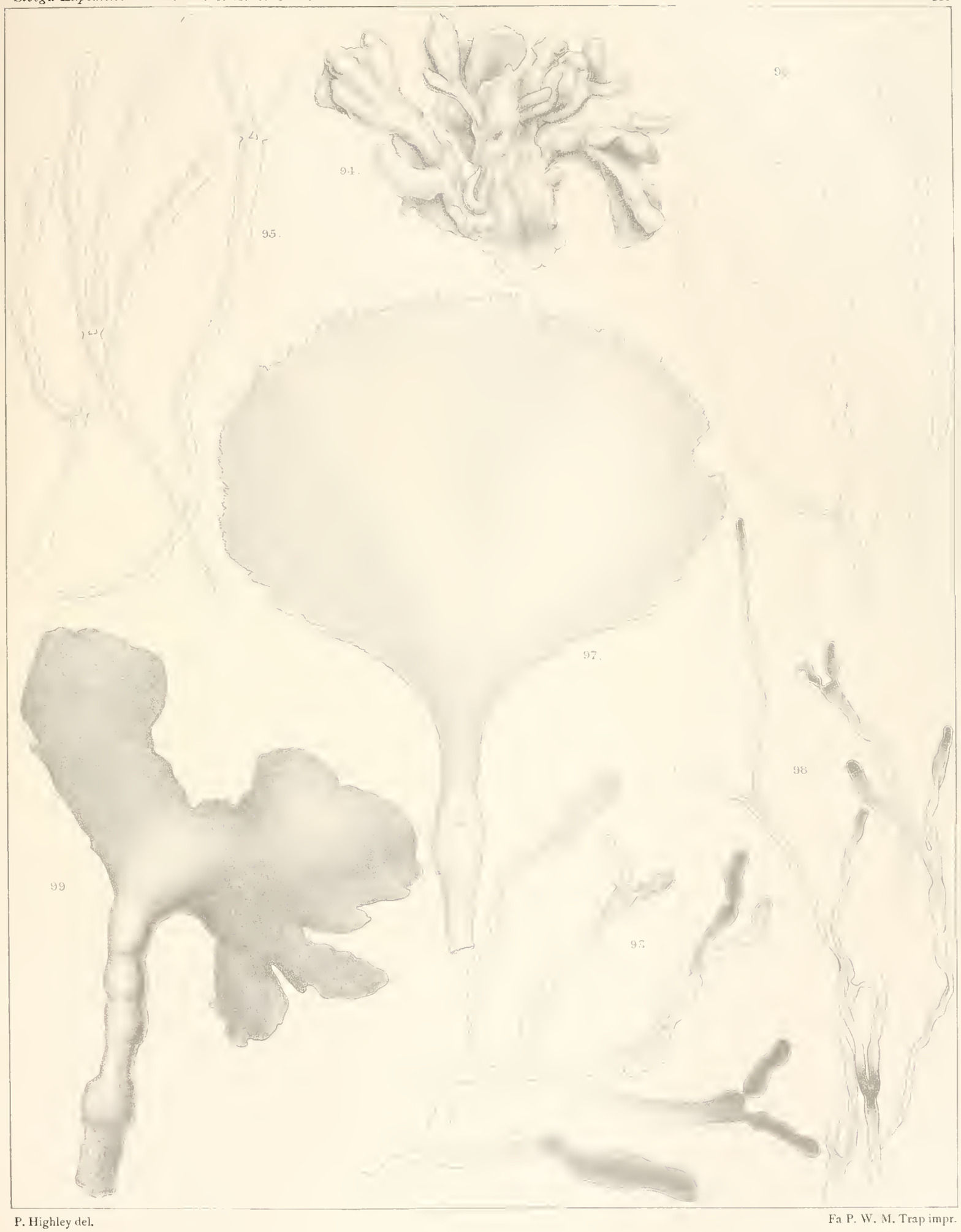

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PLATE XII.

Fig. 99*a*. *Acrauvillea Elliottii*. Habit of plant, nat. size. (Grenada, *W. R. Elliott*, spirit specimens in Herb. Mus. Brit.). [See also fig. 99 on plate XI].

Fig. 100. Ditto. Frond-filaments of same × 100. They are cylindrical, sometimes slightly torulose, colourless or brown.

Fig. 101. *Acrauvillea Gardineri* A. & E. S. Gepp. Habit of plant, $^1/_2$ nat. size (Cargados Carajos, 30 fathoms, *J. S. Gardiner*).

Fig. 102. Ditto. Frond-filaments of same × 100. They are markedly torulose, not tapering, are faintly chlorophyllose, sometimes pale brown; apices slightly tortuous, free.

Fig. 103. *Acrauvillea pacifica* n. sp. Habit of plant, nat. size. (Fualopa, Funafuti Expedition, spirit specimen in *Herb. Mus. Brit.*).

Fig. 104. Frond-filaments of same × 100. They are markedly torulose, tapering, faintly chlorophyllose, sometimes pale brown; apices tortuous or hooked.

P. Highley del.

Fa P. W. M. Trap impr.

PLATE XIII.

Fig. 105. *Avrainvillea lacerata* J. Ag. forma *typica*. Habit of plant, nat. size. (Friendly Islands, *Harvey*, n°. 86, in Herb. Mus. Brit.).

Fig. 106. Ditto. Frond-filaments of same · 100. *a*. supra-dichotomial constrictions of same · 420. The filaments are cylindrical, tapering, with apices often slightly torulose, generally not tortuous; the filaments of the interior are often yellowish-brown.

Fig. 107. Ditto. Habit of plant, nat. size. (Beo, Karakelang, reef, Siboga Expedition).

Fig. 108. Ditto. var. *robustior* n. var. Habit of plant, nat. size. (Singapore, *Ridley*; spirit specimen in Herb. Mus. Brit.).

Fig. 109. Frond-filaments of same · 100. *a*. supra-dichotomial constrictions of same, more long-necked than in the type, · 420.

Fig. 110. *Avrainvillea sordida* Murray and Boodle. Habit of type-plant, nat. size. Guadeloupe, *Mazé* n°. 30, 1ere sér. in Herb. Mus. Brit.).

Fig. 111. Ditto. Frond-filaments of same · 100. They are cylindrical, tapering, here and there torulose, rarely submoniliform, not or very slightly tortuous at apices.

P. Highley del.

Fa P. W. M. Trap impr.

PLATE XIV.

Fig. 112. *Iveraineillea amadelpha* A. & E. S. Gepp. Habit of MONTAGNE's type of *Udotea amadelpha*, nat. size. (Galega, *Le Duc*, in Herb. Mus. Paris).

Fig. 113. Ditto. Frond-filaments of same × 100. The interior filaments are often slightly torulose, and become more torulose towards their apices; the apices are very tortuous, branched, irregularly swollen, hooked and felted together into a pseudo-cortex. But the peripheral ramification of the frond filaments in MONTAGNE's type is for the most part denuded away by exposure to the action of the surf.

Fig. 114. Ditto. forma *submersa*. Habit of plant, nat. size. (Saya de Malha, 29 fathoms. *J. S. Gardiner*).

Fig. 115. Ditto. f. *submersa*. Frond-filaments of same × 100. The filaments appear thinner than in fig. 113. This is due to the more prolific and more slender ramification in f. *submersa*.

Fig. 116. *Iveraineillea asarifolia* Börgesen. Habit of type plant, nat. size. (Danish West Indies. *F. Börgesen*). (After Börgesen in Vid. Medd. nat. Foren. Kjöbnhavn. 1908. tab. III).

Fig. 117. Ditto. Frond-filaments of same × 100; *a* and *b*, cylindric interior filaments, × 100. The filaments taper somewhat and are torulose towards their apices; apices very tortuous, branched, irregularly swollen, felted together into a pseudo-cortex.

Rhipiliopsis.

Fig. 118*a* and *b*. *Rhipiliopsis peltata* n. gen. et n. comb. Habit of plant, peltate specimens, nat. size. (Port Phillip Heads, *J. Bracebridge Wilson* in Herb. Mus. Brit.).

Fig. 119. Ditto. Frond-filaments of same, showing at *ps. c.* some instances of the pseudo-conjugation of two short lateral prominences arising from neighbouring filaments. × 40.

Fig. 120. Ditto. Part of same × 200.

Fig. 121. Ditto. Portion of same showing how frequent are the pseudo-conjugations near the apices of the filaments. At x are two prominences which have been disconnected × 200.

P. Highley del.

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PLATE XV.

Fig. 122. [illegible] *peltata*. Portion of margin of frond showing young dichotomies in course of formation. The swollen little branches are sometimes very abundant and doubtless represent what AGARDH (loc. cit.) described as the cortex. 200.

Flabellaria (see also figs. 29–31 on plate IV).

Fig. 123. *Flabellaria minima* Gepp (= *Udotea minima* Ernst). Habit of plant, showing creeping, irregularly branched, colourless basal filament, emitting a few dichotomously branched, green, ascending, free filaments. 8. (after Ernst in Beih. z. Bot. Centralbl. XVI. 1904. Tab. VII. fig. 6).

Fig. 124. Ditto. Young plant showing the simplicity of structure that characterises the stipes and frond in *F. minima*. Some twenty ascending filaments have associated themselves together into a non-corticated stipes, and, branching above almost in one plane, have expanded into a flabellum. A free filament is shown alongside. 8. (After Ernst loc. cit. Tab. VII. fig. 7).

Fig. 125. Ditto. Portion of well-grown flabellum near its margin, showing the main filaments held together by the production of a few lateral branchlets which spread obliquely across them and here and there are interwoven with them. These lateral branchlets are developed only at the time of vigorous growth. 90. (after Ernst loc. cit. Tab. VIII. fig. 27).

Rhipilia.

Fig. 126. *Rhipilia tomentosa* Kutz. f. *typica*. Habit of plant, nat. size. (Antilles, *Herb. Kützing* in Herb Weber van Bosse. The original of fig. *a* in Kutzing's Tab. Phyc. VIII. tab. 28, 1).

Fig. 127. Ditto. Frond-filaments of the same, showing pseudo-lateral branchlets terminated by a 2—6-fid tenaculum of 2 or more short processes. 40.

Fig. 128. Ditto. Part of same enlarged. *a* lateral branchlets, showing tenacula applied to neighbouring branchlets. 200. *b* dichotomy in thicker main filament, showing annular ingrowths or "stoppers" 200.

Fig. 129. *Rhipilia tomentosa* f. *zonata* forma nov. Habit of plant, nat. size (St. Jan, *Börgesen* n°. 2218).

Fig. 130. *Rhipilia tenaculosa* n. sp. Habit of plant (an explanate flabelliform example), nat. size. (Off Barra Grande, 30 fathoms, near Pernambuco, "*Challenger*" Expedition in Herb. Mus. Brit.).

Fig. 131. Ditto. Another plant of the same gathering, an infundibuliformly peltate example, nat. size.

Fig. 132. Ditto. Frond-filaments beset with numerous short lateral branchlets or tenacula, and bearing a few pseudo-lateral branchlets of dichotomial origin. 40.

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PLATE XVI.

Fig. 133. *Rhiptia tenaculosa* n. sp. Portions of same. *a* Filament with short lateral tenacula. *b* Apical part of filament with pseudo-lateral branchlets terminating in tenacula. *c* Single tenaculum of lateral origin. All × 200.

Fig. 134 *a* and *b*. *Rhiptia orientalis* n. sp. Habit of plants; subpeltate and flabelliform examples of the same gathering nat. size. (Fau. Aug. 11. 1899. Siboga Expedition. Alcohol specimen).

Fig. 135. Ditto. Frond-filament of same, showing pseudo-lateral branchlets terminated by tenacula. At *a* some of them are seen attached to neighbouring filaments. × 40.

Fig. 136. Ditto. Portion of same at margin, seen in surface view, showing the very loose texture of thallus, and the reciprocal linking of the main filaments by means of the tenacula on the pseudo-lateral branchlets. × 100. *a*, *b*, *c* tenacula × 200. *d* supradichotomial constrictions of a main filament. (This character is rarely found in *Rhiptia*). × 200.

Cladocephalus (see also figs. 32—35 on plate IV).

Fig. 137. *Cladocephalus scoparius* Howe. Plant showing scopulaeform habit, nat. size. (Bahamas, *Howe* n°. 4079 in Herb. Mus. Brit.).

Fig. 138. Ditto. Frond-filament of same, dichotomously branched; the smaller branch on the left is repeatedly and densely divaricato-dichotomously subdivided into ramelli, which are intricated together to form pseudo-cortex. Dried specimen. × 178.

(For *C. luteo-fuscus* see figs. 32—35 on plate IV).

Fig. 139. *Cladocephalus excentricus*. Plant showing peltate habit, with frond concave above, nat. size. (Cargados Carajos, *J. S. Gardiner* in Herb. Mus. Brit.).

Fig. 140. Ditto. *a* Frond-filament of same, dichotomously branched; one branch is shown repeatedly dichotomously subdivided into terminal ramelli which form a pseudo-cortex. × 178. *b* Terminal ramification of a similar branch. × 178. (*a* and *b* were taken from a dried specimen.) *c* External view of natural surface of frond showing how the branched terminal ramelli are normally interwoven into a pseudo-cortex. × 280. (Alcohol specimen.)

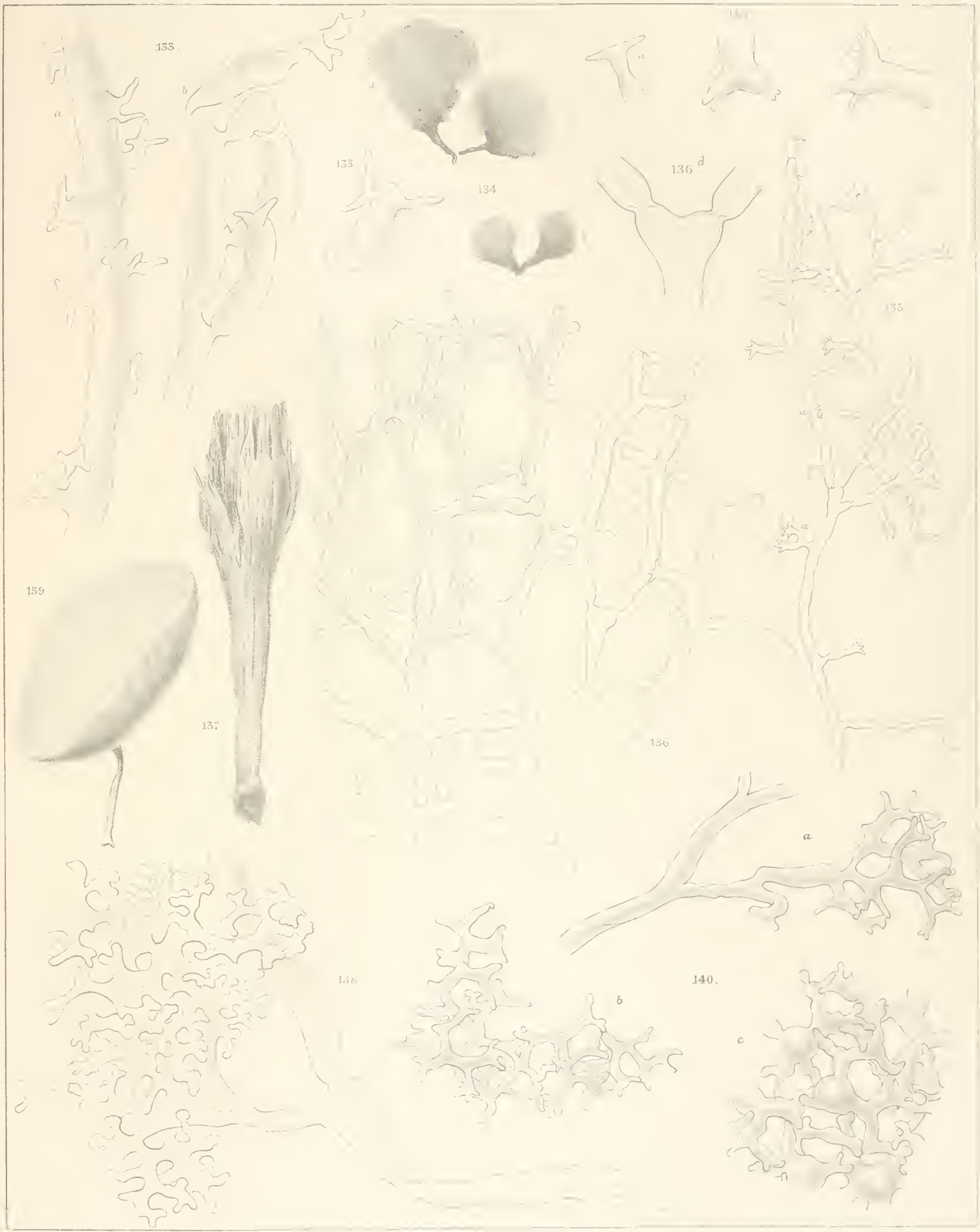

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PLATE XVII.

Fig. 140. *Chamaedoris excentricus*. Frond filament dichotomously branched, one of the branches being unilaterally subdivided into terminal ramelli. × 178. [Fig. 140*a*, *b*, *c* are on plate XVI].

Rhipidodesmis.

Fig. 141. *Rhipidodesmis caespitosa* Gepp. Plant showing tufted habit, nat. size. (Ceylon, *Ferguson*, n°. 110 in Herb. Mus. Brit.).

Fig. 142. Ditto. A plant consisting of a decumbent, irregularly branched, colourless filament, and springing from it a green ascending filament, much ramified with dichotomies distant below, but approximated above. × 8.

Fig. 143. Ditto. Apical ramification of a filament of the same, showing approximated complanate fastigiate mode of branching. The apices show intensely coloured, dense contents. × 40. (Whether the ramification has been flattened in drying we do not know).

Callipsygma.

Fig. 144. *Callipsygma Wilsoni* J. Ag. Habit of plant, nat. size. (Australia, Port Phillip Heads, *J. Bracebridge Wilson*). *a* original in Lund Herbarium; *b*, branch of same in the British Museum.

Fig. 145. Ditto. Portion of same showing peripheral ramification × 8.

Fig. 146. Ditto. Apical portion of same, × 40. (Drawn from dried material soaked in water; but represented as being more turgid than is justified by the preparation).

Boodleopsis.

Fig. 147. *Boodleopsis siphonacea* n. sp. Habit of plant, showing the comparatively simple main axis (*m.a.*) and the multitude of intricated ramelli which arise from its few branches. × 8. (Muaras reef, Siboga Expedition).

Fig. 148. Ditto. Upper part of same main axis, showing the uneven outline, the thick walls and dichotomous branching. × 40.

Fig. 149. Ditto. Lower portion of same showing thick walls, faint striae, and lax reticulate markings. × 200.

Fig. 150. Ditto. Upper part of main axis with two branches, which are copiously divided into the characteristic ramification of the plant, by divaricate alternating dichotomies at short intervals or frequently by trichotomy or rarely by verticils (*v*). A few rhizoids are shown (*rh*). × 40.

Fig. 151. Ditto. Verticillate node of same (fig. 150, *v*). × 500.

Fig. 152*a* and *b*. Ditto. Terminal ramelli of same, showing dichotomy and trichotomy. × 200.

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PLATE XVIII.

Tydemania.

Fig. 153. *Tydemania expeditionis* Weber van Bosse. Habit of glomuliferous plant, nat. size. (Spirit specimen. Saleh Bay, 8—16 fathoms, Siboga Expedition). *a*) Filament from a glomerulus of same showing dichotomous branching in alternate planes. · 16.

Fig. 154. Ditto. Portion of plant near base showing main axis with four nodes; around the axis at the upper node is situated a glomerulus, from the three lower nodes spring shortly stalked flabella. · 8. (Kabala dua, Siboga Expedition).

Fig. 155. *Tydemania Gardineri* n. sp. Portion of plant showing habit, · 8 (Amirante, *J. Stanley Gardiner*). The main axis, *a*, if traced, is seen to possess two nodes from which arise moniliform branch-systems which after 4—6 dichotomies terminate in flabella; other branches are cylindric and bear rhizoids.

Fig. 156 on plate XIX.

Penicillus.

Fig. 157. *Penicillus dumetosus* Decne. Habit of LAMOUROUX's type (badly figured in his Hist. Polyp. Corall. Flex. tab. VIII. fig. 3), nat. size. (Antilles, sub nom. "*Nesaea dumetosa*" in *Herb. Lamouroux*).

Fig. 158. Ditto. *a*. Comal filament of Decaisne's plant ("Antilles. Voyage du Cap. *Baudin*") in Herb. Mus. Paris. · 5 (after decalcification). *b*. dichotomy about 30. [Fig. 158*c* and *d* on plate XIX.]

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PLATE XIX.

Fig. 156. *Penicillus dumetosus* Decne. Habit of plant, nat. size. (Florida, *Howe* n°. 2952).

Fig. 157 is on plate XVIII.

Fig. 158. Ditto. *c*. Comal filament of specimen in Herb. Decaisne, × 5 (after decalcification) (Antilles, sub nom. "*Nesea pyramidalis* Lmx." see p. 78); *d*. dichotomy × about 30. [Fig. 158*a* and *b* are on plate XVIII].

Fig. 159. Ditto. *a*. Surface view of papillose cortex of stipes before decalcification, × 83. (Florida, *Howe* n°. 2952). *b*. filament of stipes of same with lateral appendages, dichotomously divided and terminated by blunt dactyline apices (= papillae of fig. *a*) after decalcification, × 83.

Fig. 160. *Penicillus Lamourouxii* Decne. Habit of plant, nat. size. (Banc de Bahama, sub nom. "*Nesea dumetosa*" in *Herb. Lamouroux*; the best of the type specimens cited by DECAISNE).

Fig. 161. Ditto. Comal filament of same (calcified), × 5.

Fig. 162. Ditto. var. *gracilis* A. & E. S. Gepp. Habit of plant, nat. size (Key West, Florida, *Howe* n°. 1412*b*). Half the capitulum has been cut away, and the stipes split open to show its hollowness, its thin wall, and its short penetration into the capitulum.

Fig. 163. Ditto. *a*. surface view of cortex of stipes before decalcification, × 83 (Florida, *Howe* n°. 1412*b*). *b* filament of stipes of same with lateral appendages dichotomously divided and terminated by short truncate apices (compare fig. *a*), after decalcification, × 83.

Fig. 164. *Penicillus capitatus* Lamarck. Habit of plant, nat. size. (Coll. de LAMARCK in Herb. Mus. Paris; labelled in DECAISNE's MS.).

Fig. 165. Ditto. Portion of a comal filament of same (after decalcification), *a* × 5; *b* × 15.

Fig. 166. Ditto. forma *elongata*. (Banc de Bahama, sub nom. "*Nesea Penicillus* var." in *Herb. Lamouroux*. see p. 84).

Fig. 167. Ditto. Comal filament of same (after decalcification), *a* × 5 showing at base a few of the lateral appendages which contribute to the formation of the stipes-cortex); *c*. dichotomy × about 60. [Fig. 167*b* is on plate XX].

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PLATE XX.

Fig. 167. *Penicillus capitatus* Lamarck forma *elongata*. Comal filament (part of fig. 167 *a*) × 15. [Fig 167 *a* and *c* are on plate XIX].

Fig. 168. *Penicillus capitatus* Lamarck. *a*. surface view of cortex of stipes before decalcification, × 83 (Florida, *Howe* n°. 1412). *b*. the same 225. *c*. Filament of stipes of same with lateral appendages dichotomously divided and terminated by very small short truncate apices (compare fig. *a*), after decalcification, 83.

Fig. 169. *Penicillus pyriformis* A. & E. S. Gepp. Habit of plant, nat. size. (Bahamas, *Howe* n°. 3236).

Fig. 170. Ditto. Comal filament of same (calcified), × 5.

Fig. 171. Ditto. *a*. surface view of papillose cortex of stipes before decalcification, × 83 (Bahamas, *Howe* n°. 3230). *b*. filament of stipes of same with lateral appendages dichotomously divided and terminated by tapering, acute, dactyline apices (= papillae of fig. *a*) after decalcification, × 83.

Fig. 172. *Penicillus nodulosus* Blainville. Habit of plant, nat. size. (Ile Toud, *D'Urville*, sub nom. *Penicillus arbuscula* Montag.; labelled in MONTAGNE's MS.).

Fig. 173. Ditto. Comal filament of specimen in Herb. Lamouroux, 5 (labelled by Lamouroux: — "28 Freycinet — *Nesea nodulosa*"; also "*Nesea granulosa. Freycinet.* Baie des Chiens marins"). The right hand branch shows how the dichotomies lie in alternating planes. *a*. dichotomy about 25.

Fig. 174. Ditto. Comal filament of one of HARVEY's specimens, × 5 (Fremantle, West Australia. *Harvey* Alg. exsicc. n°. 564). *a*. dichotomy about 25.

Fig. 175. Ditto. *a* surface view of cortex of stipes before decalcification, 83 (West Australia, *Clifton*, n°. 204 in Herb. Mus. Brit.). *b*. Filament of stipes of same with lateral appendages dichotomously divided and terminated by short capitate or rounded apices (compare fig. *a*), after decalcification 83.

Fig. 176. *Penicillus mediterraneus* Thuret. Habit of DECAISNE's type-plant of *Espera mediterranea*, nat. size (Villefranche. *Risso* in Herb. Mus. Paris). An abnormally large specimen.

Fig. 177. Ditto. Ascending filament (calcified) of another specimen (Cannes, ex Herb. Thuret in Herb. Mus. Brit.) *a* × 5; *b*, dichotomy · 15.

Fig. 178. Ditto. forma *perfecta*, nat. size. (Antibes, ex *Herb. Thuret*, n°. 4209 in Herb. Mus. Brit.).

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PLATE XXI.

Fig. 179. *Penicillus mediterraneus* Thuret. Comal filaments (calcified) of same, *a* 5; *b*, dichotomy 15.

Fig. 180. Ditto. *a*. surface view of cortex of stipes before decalcification, 83 (Antibes, ex *Herb. Thuret* n°. 4200). *b* the same 225. *c*. filament of stipes of same with lateral appendages dichotomously divided and terminated by very small short truncate apices (compare fig. *a*), after decalcification. 83.

Fig. 181, 181*a*. *Penicillus Sibogae* n. sp. Habit of plant, 8. (Noimini Bay, Timor, Siboga Expedition). It resembles the *Espera* form of *P. mediterraneus*, but has its filaments smaller, frequently beaded, often trichotomous. At *x* is shown a lateral cohesion between two adjacent ramuli, probably fortuitous.

Fig. 182. Ditto. Apex of a filament of same, showing porose calcareous sheath, 110.

Rhipocephalus.

Fig. 183. *Rhipocephalus phoenix* Kutz. f. typica A. and E. S. Gepp. Habit of plant, nat. size. Copied from ELLIS and SOLANDER's plate (loc. cit.).

Fig. 184. Ditto. f. *brevifolia* A. & E. S. Gepp. Habit of plant (spirit specimen), nat. size (Bahamas, Bemini Harbour, *Howe* n°. 3239).

Fig. 185. Ditto. Calcified flabellule of same (n°. 3239) 15. The filaments arise by repeated dichotomies in the same plane and are laterally connate. The articuli in this form remain very short. The base has been torn out of the rhachis and retains the stumps of six lateral appendages of the cortex.

Fig. 186. Ditto. *a* surface view of cortex of stipes before decalcification, 83 (Bahamas, *Howe*, n°. 3239. *b*. the same 225. *c*. filament of stipes of same with lateral appendages dichotomously divided and terminated by very narrow, crowded, truncate apices (compare fig. *a*), after decalcification. 83. *d* apical ends of same 420.

Fig. 187. Ditto. f. *longifolia* A. & E. S. Gepp. Habit of plant, nat. size (Key West, Florida, *Howe* n°. 1612).

Fig. 188. Ditto. Abnormally large plant of same, nat. size. (Florida, *Rugel*, in Herb. Mus. Brit.).

Fig. 189. *Rhipocephalus oblongus* Kutz. Habit of plant, pressed specimen, nat. size. (Bahamas, in *Herb. Mus. Paris*, sub nom. "*Penicillus Lamourouxii* Dne.", but probably DECAISNE's type of his *Penicillus oblongus*, see p. 99).

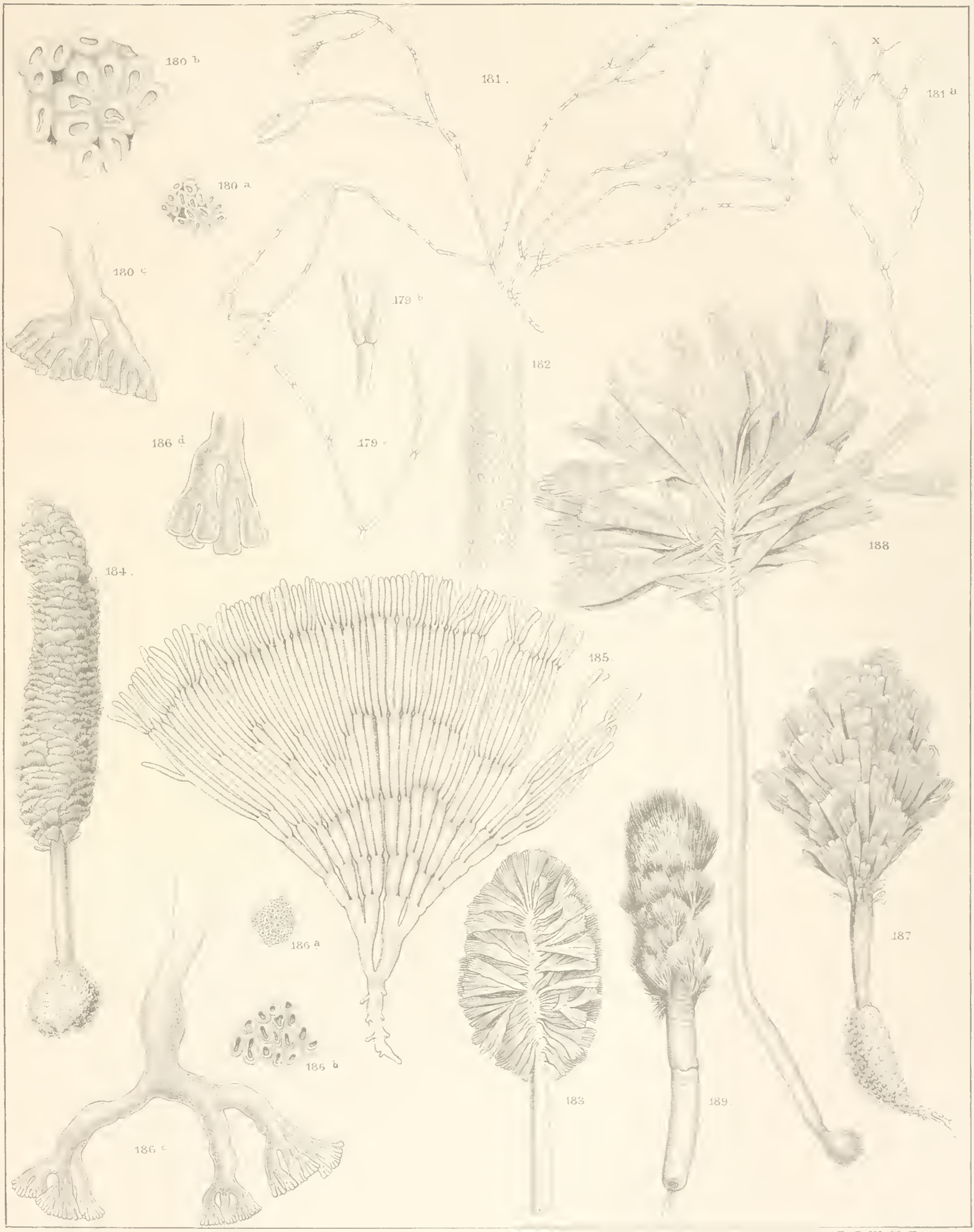

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PLATE XXII.

Fig. 100. *Halicephalus oblongus* Kutz. Part of a comal flabellum of the same; *a*. 5; *b*. 15. The dichotomies are seen to be all in one plane; but the filaments are free (not laterally connate). The four lower tiers of articuli are short and of nearly equal length.

Fig. 101. Ditto. Habit of unpressed plant (spirit specimen), nat. size. (Bahamas, *Howe* n°. 3235). The apical hollow is indicated, but is better shown in *a* (represented as seen from above; nat. size), where the young apical flabellules are clearly revealed.

Fig. 102. Ditto. *a*. surface view of cortex of stipes before decalcification · 83 (Bahamas, *Howe*, n°. 3235). *b*. the same 225. *c*. filament of stipes of same with lateral appendages dichotomously divided and terminated by narrow, more or less dactyline obtuse apices (compare fig. *a*), after decalcification, 83.

Codium.

Fig. 103. *Codium petaloideum* n. sp. Habit of plant nat. size. (Borneo bank, Sabangkatan, reef. Siboga Expedition). *a*. surface view; *b*. profile.

Fig. 104. Ditto. Utricles of same, 83. They are subpyriform, obtusely rounded above, or often impressed.

Fig. 105. *Codium divaricatum* n. sp. Habit of plant, nat. size. (Elat Kei Island, reef. Siboga Expedition).

Fig. 106. Ditto. Small plant (spirit specimen), closely applied to a stone, being attached here and there by rhizoids, nat. size. (Kwandang Bay, on *Galaxaura lapidescens*, Siboga Expedition).

Fig. 107. Ditto. Utricles of same. 83.

Fig. 108. Ditto. Rhizoids, of medullary origin, passing between the utricles on their way out of the thallus, 83.

Fig. 109. Ditto. Apical point of attachment, 425.

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RÉSULTATS DES EXPLORATIONS
ZOOLOGIQUES, BOTANIQUES, OCÉANOGRAPHIQUES ET GÉOLOGIQUES
ENTREPRISES AUX
INDES NÉERLANDAISES ORIENTALES en 1899—1900,
à bord du SIBOGA
SOUS LE COMMANDEMENT DE
G. F. TYDEMAN
PUBLIÉS PAR
MAX WEBER
Chef de l'expédition.

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including a Monograph of FLABELLARIEAE and UDOTEAE

BY

A. & E. S. GEPP
London

With 22 plates

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UITKOMSTEN OP ZOOLOGISCH, BOTANISCH, OCEANOGRAPHISCH EN GEOLOGISCH GEBIED

verzameld in Nederlandsch Oost-Indië 1899—1900

aan boord H. M. Siboga onder commando van
Luitenant ter zee 1e kl. G. F. TYDEMAN

UITGEGEVEN DOOR

Dr. MAX WEBER
Prof. in Amsterdam, Leider der Expeditie

(met medewerking van de Maatschappij ter bevordering van het Natuurkundig Onderzoek der Nederlandsche Koloniën)

BOEKHANDEL EN DRUKKERIJ
VOORHEEN
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LEIDEN

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